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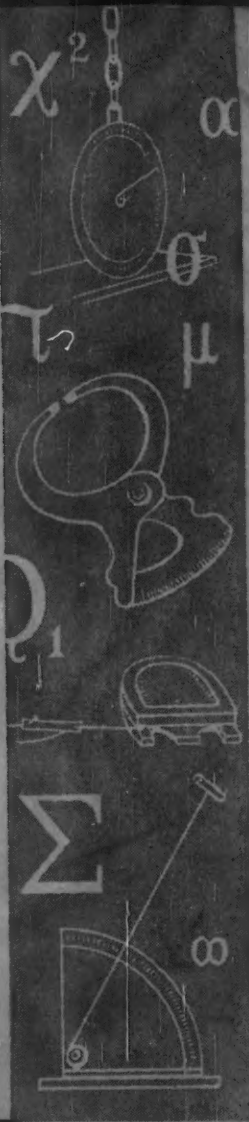

AMERICAN ASSOCIATION FOR HEALTH PHYSICAL EDUCATION AND RECREATION

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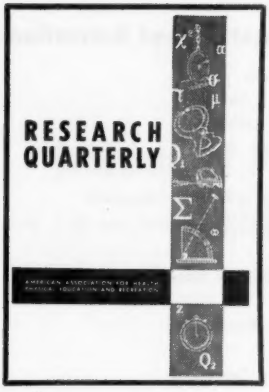
December 1961

Announcement to Members

At its annual convention in April 1960, the American Association for Health, Physical Education, and Recreation took decisive action to assist in raising standards of professional preparation, linking this action with a new AAHPER membership requirement.

- The Association designated the National Council for the Accreditation of Teacher Education as the official accrediting agency for teacher education in health, physical education, and recreation. Appropriate organizations and agencies are being urged to support NCATE accreditation in every possible way.

- The Association also stipulated that after June 1, 1964, *all new* professional, fellow, life, and life fellow members must have at least one graduate or undergraduate degree, with a major or minor in health, physical education, or recreation, from an NCATE-accredited institution. After this date, any person who permits his membership to lapse more than one year must fulfill the requirement made of *new* members. Persons applying for membership after June 1, 1964, who do not meet the above requirement may be designated as associate members. (An article in the May-June 1961 JOURNAL describes the functions and procedures of the NCATE and lists the NCATE accredited institutions offering degrees in health education, physical education, and recreation.)



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Relations of Power, Speed, Flexibility, and Certain Anthropometric Measures of Junior High School Girls

LLOYD R. BURLEY
University of New Mexico
Albuquerque, New Mexico
HELEN C. DOBELL
BETTY J. FARRELL
Monroe Junior High School
Albuquerque, New Mexico

Abstract

This study was conducted to determine the differences among 7th, 8th, and 9th grade girls in power, speed, and flexibility and to determine the relation between power and flexibility, speed and flexibility, and speed and certain anthropometric measures. The subjects were enrolled in ungraded physical education classes. Seventh grade girls were faster than 8th grade girls in the 50-yard dash. Ninth grade girls broad jumped farther than 7th and 8th grade girls. No significant relations were found in the other items studied.

RENEWED EMPHASIS upon physical fitness has focused attention upon the need for further analysis of the elements of fitness and their relationships. Such study enables us to make the best selection of activities for the development of fitness. It is important to measure pupils regularly to determine their progress in the development of the aspects of fitness under various programs. It might be expected that flexibility and lever length would influence speed and power since these factors determine the distance over which force can be applied. Knowledge of such relationships would assist in choosing activities and in understanding the capabilities of pupils.

The purpose of this study was to determine the differences among 7th, 8th, and 9th grade girls in flexibility, power, and speed and to determine the relation between power and flexibility, speed and flexibility, and speed and certain anthropometric measurements.

Review of Related Literature

Although Tyrance (9) found that there was some correlation between flexibility and specific extremes of body type, Broer and Galles (1) found that for persons of average build, the relation of trunk plus arm length to leg length and of weight to height were not important factors affecting the ability to perform the toe-touch. Matthews, Shaw, and Bohnen (5) found no significant relation between flexibility of hip and leg length in 66 college women. Rasch (7) found no statistically significant correlation between the speed of arm movement and weight, strength, and length of arm.

The relation of flexibility to age has been studied. Phillips (6) gave Kraus-Weber tests to boys and girls from 6 to 12 years of age. She concluded that both sexes tend toward a rapid decrease in flexibility with increased age, the flexibility of the girls de-

creasing more rapidly. Hupprich and Sigerseth (2) measured the flexibility in 12 joints in girls. They concluded that flexibility is a factor specific for each joint and that flexibility tends to increase in most joints until age 12, or adolescence, is reached, then decreases gradually. However, a gradual decrease in shoulder, knee, and thigh flexion was noticed from ages 6 to 18.

It would seem likely that the activity of the subject would influence these tendencies in flexibility. McCue (4) administered five flexibility tests to college women and repeated them after three weeks of mild exercises. She found a significant increase in flexibility. Eight weeks after the completion of the exercise period she found that three of the five movements studied remained at significant difference levels. Sigerseth and Haliski (8) found normal college men significantly more flexible than football players in 13 of 21 joints or areas. Only in side trunk-hip flexion were the football players significantly more flexible.

Subjects

Data were obtained from girls' ungraded physical education classes at Monroe Junior High School at Albuquerque, New Mexico. Since there were no apparent differences among the 12 classes available, five were drawn at random. From these five classes a random selection of 33 girls from the 7th grade, 34 from the 8th, and 33 from the 9th grade was made to supply 100 subjects for the study. The girls wore blue jeans and light weight blouses. The tests were administered by two women physical education instructors working together.

Description of the Tests Used

FLEXIBILITY TESTS

The Leighton Flexometer was used to measure the flexibility of the wrist, elbow, shoulder, knee, hip-thigh, and ankle. All flexibility measures were taken on the right side of the subject. The procedures recommended by Leighton (3) were followed excepting that in the hip-thigh measurement a double thickness of three-inch elastic was attached to the tightening band of the flexometer, pulled snug, and secured with a large safety pin. The elastic band replaced an inelastic cuff and allowed for the contraction and expansion of the muscles of the thigh.

POWER TESTS

Two tests of power, the basketball throw for distance and the standing broad jump, were administered to the girls. One period of 50 minutes was allowed for demonstration and practice. The highest score of three attempts was recorded.

Basketball Throw for Distance. A line two feet long was marked on the ground, and a Lufkin steel tape was nailed into the center of the line. Two chairs were placed 10 feet apart and 20 feet distant from the line. This formed a 10 foot lane into which the ball was required to fall in order to score. The subject toed the line with one foot and placed the other in a comfortable position to the rear. The ball was held in front of the body with both hands at the start. The throwing arm was brought back past the cheek with the elbow bent and with the ball held in the palm of the hand. The ball was thrown forward with an overhand motion. Both feet maintained contact with the ground throughout the throw. Measurements were taken to the nearest foot.

Standing Broad Jump. A take-off board (5″ x 1′ 5″) was placed in the ground, and a landing pit containing a mixture of sawdust and dirt was prepared. Each girl was instructed to place her feet on the board with the toes just touching but not over the

front edge in the starting position. Both arms were raised above the head and then brought down and back while the knees were bent simultaneously and then the jump was executed. Girls were further instructed to land on both feet and to move forward out of the pit. Each jump was measured. The measurement was taken from the edge of the board closest to the pit to the imprint of the heel or other part of the body closest to the board. The best of three jumps was recorded to the nearest inch.

SPEED TEST

The 50-yard dash was given as a test of speed. A class period of 50 minutes was allowed for demonstration and practice. The start and finish lines for the dash were marked on the ground. Each subject initiated the run from a stride standing position when a flag was dropped. This event was timed to the nearest tenth of a second.

ANTHROPOMETRIC MEASUREMENTS

A Detecto Doctor's Scale with stadiometer was used to measure the height and weight of each subject. Four appendage measurements were taken: from the olecranon process to the ungual tuberosity; from the acromion process to the olecranon process; from the greater trochanter to the lateral condyle of the tibia; from the lateral condyle of the tibia to the lateral malleolus. Appendage lengths were taken on the right side and recorded to the nearest 1/16 in.

Differences between Grades

A chi square analysis was used to test the hypothesis that the subjects in the three grades were from the same population as determined from their average scores in the 50-yard dash, standing broad jump, basketball throw, and flexibility measures. An X^2 of .1147 was found for the 50-yard dash, which could be expected 92 percent of the time with two degrees of freedom, thus supporting the hypothesis. An X^2 of .3228 was found when the broad jump scores were examined. This could be expected to occur 85 percent of the time with two degrees of freedom, thus supporting the hypothesis. An X^2 of .447 was found for basketball scores, which could be expected to occur 85 percent of the time with two degrees of freedom, thus supporting the hypothesis. In the flexibility measures chi square ranged from .0010 to .3502. This could be expected to occur from better than 80 percent to better than 99 percent of the time with two degrees of freedom, thus supporting the hypothesis.

Flexibility. Table 1 presents the mean scores, standard deviations, standard errors of the means, and significance ratios of the flexibility measures for the three grades. Significance ratios indicate that the differences between the various mean scores could be due to chance. From these data it is postulated that the flexibility of these junior high school girls does not vary significantly at these three grade levels.

Power. Table 2 presents 7th, 8th, and 9th grade mean scores for the standing broad jump and basketball throw for distance with their standard deviations, standard errors of the means, and significance ratios. In the standing broad jump the mean score of the 9th grade girls was significantly better than that of the 7th and 8th grade girls. Other differences between grades in standing broad jump and basketball throw were not statistically

TABLE 1.—COMPARISON OF FLEXIBILITY MEASURES FOR 7TH, 8TH, AND 9TH GRADE GIRLS

Flexibility Measure	Mean Scores by Grades				Standard Deviations by Grades				Standard Error of Mean by Grades				Significance Ratios by Grades		
	7th	8th	9th	All	7th	8th	9th	All	7th	8th	9th	All	7-8	8-9	7-9
Ankle	64.91	65.59	67.00	65.79	9.00	8.67	9.27	8.97	1.55	1.49	1.61	.90	.32	.64	.94
Knee	130.27	129.65	127.33	129.50	12.70	16.38	12.55	14.28	2.21	2.81	2.18	1.43	.17	.65	.95
Hip-thigh	121.67	122.85	126.85	124.27	15.40	14.00	17.50	15.26	2.57	2.40	3.05	1.53	.34	1.03	1.30
Wrist	146.82	152.32	149.00	149.34	13.95	20.80	16.59	17.92	2.43	3.56	2.89	1.79	1.27	.72	.58
Elbow	161.45	160.97	160.91	162.31	8.58	8.13	9.30	8.97	1.49	1.39	1.62	.90	.23	.03	.25
Shoulder	265.36	268.21	278.21	270.16	26.01	21.07	33.21	27.54	4.53	3.61	5.78	2.75	.49	1.52	1.79

TABLE 2.—COMPARISON OF SCORES ON BROAD JUMP, 50-YARD DASH, AND BASKETBALL THROW

Tests	Mean Scores			Standard Deviations			Standard Error of Mean			Significance Ratios		
	7th	8th	9th	7th	8th	9th	7th	8th	9th	7-8	7-9	8-9
Broad jump (inches)	67.3	67.4	74.29	6.57	7.70	5.30	1.14	1.32	.92	.057	4.07	3.03
Basketball throw (feet)	31.40	31.12	36.21	4.97	6.70	9.76	.866	1.15	1.7	.19+	2.52	2.48+
Fifty-yard dash (secs.)	7.43	7.85	7.44	.501	.594	.582	.087	.102	.101	3.13	.075	2.86

significant. It was noted that the standing broad jump scores in this study appeared high compared to the norms listed in the *AAHPER Youth Fitness Test Manual.*

Speed. Table 2 presents 7th, 8th, and 9th grade mean scores for the 50-yard dash with their standard deviations, standard errors of the means, and significance ratios. The mean score of the 8th grade was .4 second greater than the mean for the 7th grade. This difference was statistically significant, with a significance ratio of 3.13. Other differences in speed between the grades were not significant. The speed scores in this study appeared high when compared to the norms in the *AAHPER Youth Fitness Test Manual.* High scores in performance tests indicate excellence in performance, and it is more difficult to improve at the upper range of perfection.

Relations between Total Group Measures

Flexibility and Power. It would seem that flexibility might contribute to power by increasing the distance over which the force could be applied. The flexibility measures of the 100 girls were compared with their scores in the basketball throw for distance test and the standing broad jump test by means of the Pearson product-moment method of correlation. The correlation between basketball throw scores and shoulder flexibility (.085), elbow flexibility (.11), and wrist flexibility (.043) indicated that the flexibilities of the joints of the upper appendage were not closely related to the basketball throwing ability of these junior high school girls.

Similarly, the correlations of the standing broad jump with knee flexibility (.129), ankle flexibility (.103), and hip-thigh flexibility (.157) indicated that the flexibilities of the joints of the lower appendage were not closely related to the broad jumping ability of these junior high school girls.

Speed, Flexibility, and Anthropometric Measures. Six flexibility measures and six anthropometric measures were correlated with scores made in the 50-yard dash to determine the relation between these variables. When the speed score for each subject was correlated with each of her flexibility measures, no coefficient of correlation greater than —.163 was obtained. For these subjects, flexibility of the appendages was not significantly related to their speed in running a 50-yard dash.

When the speed scores were correlated with the subjects' heights and weights, correlations of .183 and —.003 were obtained. When the speed scores were correlated with the various lever lengths of the subjects, the following correlations were obtained: speed and olecranon to ungual tuberosity .161; speed and olecranon to acromion process .120; speed and greater trochanter to the lateral condyle of the tibia .184; and condyle of the tibia to lateral malleolus .073. All of these correlations indicate a neutral relation between speed and the anthropometric measures used in this sample.

Conclusions

These findings indicate that power, speed, and flexibility, as measured by the tests used, did not increase or decrease with the increased age and

growth of these girls enrolled in ungraded classes during their junior high school years. Since low degrees of relationship were found between flexibility and power and flexibility and speed, it would appear desirable to plan a training program which would provide for the specific development of each of these factors.

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(Submitted June 27, 1960)

Relation of Maturity, Structural, and Strength Measures to the Somatotypes of Boys 9 Through 15 Years of Age[1]

H. HARRISON CLARKE
University of Oregon
Eugene, Oregon
ROBERT N. IRVING
Sacramento County Schools Office
Sacramento, California
BARBARA HONEYMAN HEATH
Monterey, California

Abstract

The purpose of this study was to relate the somatotypes of boys to their skeletal maturity, structural characteristics, and muscular strength. Five somatotype categories were formed: endomorphs, mesomorphs, endomesomorphs, ectomorphs, and mid-types. The subjects were 259 boys, 37 boys at each age 9 to 15 years inclusive. In general, the endomorphs and endomesomorphs were largest in such body measures as body weight, chest girth, upper arm girth, calf girth, and hip width. The mesomorphs showed general superiority in both gross and relative muscular strength and muscular endurance measures. The ectomorphs and mid-types followed somewhat the same pattern, although some differences between these two categories did exist. The only tests where no difference between means was found were sitting height, leg length, Classification Index I, and lung capacity. A significantly greater percentage of endomesomorphs were advanced than were retarded; the reverse was true for the mid-type boys.

THIS STUDY PROPOSED TO RELATE the somatotypes of boys 9 through 15 years of age to their skeletal maturity, structural characteristics, and muscular strength. The somatotypes were rated basically in accordance with Sheldon's designations, with some modifications explained herein.

The studies reported by others in which somatotype assessments have been related to anthropometric, strength, and motor ability measures have been conducted mostly with college men so may not be applicable to boys of the much younger ages utilized in this investigation, The following results have been reported in studies with college men. Correlations obtained by Willgoose and Rogers (9) between primary somatotype components and the Physical Fitness Index were —.93 for endomorphy, .52 for ectomorphy, and

[1] This study was conducted with data obtained from the Medford, Oregon, Boys' Growth Study. Subsidization of the Growth Study was provided by Medford Public Schools, Southern Oregon College, Athletic Institute (Chicago, Illinois), Oregon State Education Department, and Office of Scientific and Scholarly Research of the University of Oregon. The superintendent of the Medford Schools, Leonard A. Mayfield, and the director of physical education, Lee Ragsdale, as well as Theodore Schopf, Southern Oregon College, are recognized for their special assistance.

.09 for mesomorphy. Hawthorne (4) reported correlations of .62 between mesomorphy and the Strength Index, .51 between ectomorphy and the vertical jump, and .43 between ectomorphy and the Brace test. After extensive investigation, Cureton (1) concluded that body build should be considered as a basic framework of reference for the interpretation of physical fitness and athletic performance.

Several investigators have related maturation to somatotype components. Hunt, Cooke, and Gallagher (5) found that mesomorphy was associated with early maturation. Zuk (10) concluded that greater maturational development in males occurred in the mesomorphic component; in females, in the endomorphic component.

Procedures

SUBJECTS

The subjects were 259 boys in the Medford, Oregon, public schools; 37 boys were chosen randomly at each age from 9 through 15 years. All tests were administered within two months of each boy's birthday.

SOMATOTYPE ASSESSMENTS

The equipment used in taking the somatotype photographs of the subjects was in accordance with specification in the *Atlas of Men* by Sheldon, Dupertius, and McDermott (11). In taking the photographs, the subjects wore only tight-fitting shorts or athletic supporters. Socks, jewelry, and glasses were removed. Frontal, lateral, and rear pictures were taken. The subjects were posed as prescribed. The somatotype assessments were made by one of the authors (Heath).[2]

High ratings in the first component, endomorphy, were assigned to physiques which tended toward spheroid shape and soft texture; at the low end of the scale, while fatness was rated, leanness was described. High ratings in the second component, mesomorphy, were given to physiques with prominent musculatures, thick bones and solid texture; low ratings were made when bodies had light musculature and relatively small, narrow bones. The third component, ectomorphy, was rated largely, but not entirely, in terms of the ratio between height and the cube root of weight. This component, then, reflects the manner and degree to which the first and second components were distributed longitudinally over the body and its segments; high ratings were given to physiques with relative elongation of the several body segments and high ratios between height and cube root of weight; low ratings were given to physiques with relatively short body segments and low ratios between height and cube root of weight.

SOMATOTYPE CATEGORIES

The use of categories for the classification of somatotypes was selected as the basic method of analysis for this study. The 19 categories suggested by Sheldon, Stevens, and Tucker (8) dispersed the data too greatly when

[2] This assessor was associated for five years with William H. Sheldon in the evaluation of male and female somatotypes; she has also served as consultant for several other studies involving the somatotyping of children and adults.

applied to the smaller number of subjects available for this research. The four categories utilized by Glueck and Glueck (2) were considered, but it was felt that their groupings obscured some of the physique categories which should be scrutinized in a study related to physical performances. This was true for three reasons. (a) Dominance of a component in their classification scheme occurred where one component designation was above the other two. Thus, a 3 4 3 was a mesomorph, despite the fact that mesomorphy is still at a midposition on the scale. (b) A similar situation existed for balanced somatotypes. Thus, a 4 4 2 was an endomesomorph, again despite the fact that none of the components exceeded the mid-position. (c) No separate classification was provided for a combination of high endomorphy and high mesomorphy, such as a 5 5 2. It was felt that this somatotype, because of the combination of body bulk and implied power, might have special significance for physical education and athletics.

As a result of these considerations, a different somatotype classification scheme was adopted with five categories (9) as follows:

Endomorphs (18 subjects): endomorphic component of 5 and over; no other component above 4.

Mesomorphs (54 subjects): mesomorphic component of 5 and over; no other component above 4.

Ectomorphs (63 subjects): ectomorphic component of 5 and over; no other component above 4.

Endo-mesomorphs (26 subjects): mesomorphic component of 5 and over; endomorphy of 4 and above; ectomorphy below 4.

Mid-types (98 subjects): no component exceeding 4.

EXPERIMENTAL VARIABLES

Twenty-two experimental variables were included in this study, as follows:

Maturity measure: skeletal age. Skeletal age was obtained from wrist-hand x-rays, assessed in accordance with the Greulich-Pyle *Atlas* (3).

Structural measures: body weight, standing height, sitting height, leg length, chest girth, flexed-tensed upper arm girth, calf girth, hip width, and lung capacity. Two derived measures were included based on the above structural measures: (a) Wetzel physique channel—nine interval channels, based on weight for boy's height; channels designated obese, stocky, good, fair, border-line, and poor "clinical" ratings, (b) McCloy's Classification Index I (20 Age + 6 Height + Weight).

Gross muscular strength and endurance measures: sum of right and left grips, back lift, and leg lift. Four gross derived scores were used based on measures of muscular strength and endurance: (a) Rogers' arm strength score—(.1 Weight + Height—60) (Push-ups + Pull-ups), (b) McCloy's arm strength score—1.77 (Weight) + 3.42 (Chins or Dips)—46, (c) Rogers' Strength Index —sum of Rogers' arm strength score, right and left grips, back and leg lifts, and lung capacity, and (d) average of the following 12 Clarke's cable-tension strength tests—elbow flexion; shoulder flexion and inward rotation; trunk flexion and extension; hip flexion, extension, and inward rotation; knee flexion and extension; and ankle dorsal and plantar flexions.

Relative muscular strength and endurance measures: number of pull-ups or chins, number of push-ups from the parallel bars, and Rogers' Physical Fitness Index.

Analysis

In grouping the subjects into the five somatotype categories, it was assumed that the distributions of somatotypes by age would be comparable for these classifications. A check on this assumption revealed that it was reasonably well met for endomorphs, endomesomorphs, and mid-types. However, there were more mesomorphs in the younger ages and more ectomorphs in the older ages. Inasmuch as most of the experimental variables increase morphs were at a disadvantage and the ectomorphs had an advantage for some tests when compared with the endomorphs and endomesomorphs.

In this study, therefore, the data were analyzed for the five categories with all ages included; this procedure is known herein as the *original* analysis. In addition, a second analysis was made, known as the *supplementary* analysis. Since there were sufficient number of boys at ages 10 and 14 years in the mesomorph, ectomorph, and mid-type categories to permit comparisons, the differences between these groups for certain of the variables were determined. Thus, for the supplementary analysis, the effects of age upon the results were eliminated. It may still be contended, however, that the mesomorphs were at a disadvantage and the ectomorphs had an advantage for some tests when compared with the endomorphs and endomesomorphs.

The basic statistical procedure used in the analysis of data consisted of testing the significance of the differences between the means of the experimental variables for the various somatotype categories by application of the t ratio. For some variables, the means of the highest and lowest 25 percents of the boys were also compared in the same manner. A problem was encountered in reaching conclusions where findings in the original analysis differed from the supplementary analysis of the 10 and 14 year old boys. In these instances, findings based on the data from the 10 and 14 year old boys took precedence, as the variances introduced by age were not present. For this study, significance for the difference between means was accepted at the .05 level.

Results

In the summary of results which follows, tables are presented which contain a consolidation of the various t ratios obtained for the original analysis only.[3] However, notations are made in the tables wherever significance was reduced to insignificance, insignificance was changed to significance, or significance was reversed in favor of the other category upon analyzing data for the 10 and 14 year old boys.

MEDFORD VS. SHELDON'S SOMATOTYPE DISTRIBUTIONS

The distribution of the somatotypes of the 259 boys in this study was compared with Sheldon's distribution based on 46,000 adult American males

[3] Full details pertaining to the results of this study may be found in Irving's doctoral dissertation (9).

(7). The number of boys in each of the five somatotype categories was converted to a percentage of the total number in the study; similarly, the number of *all* individual adult somatotypes within each of the same categories as listed in *Atlas*, was converted to a percentage of the total. These two percentage distributions were compared by means of the chi square test. The computed chi square was 5.69; in order to be significant at the .05 level, the chi square value must equal 9.49. Thus, it may be concluded that the somatotype distribution of Medford boys was not significantly different from Sheldon's distribution of adult American males.

MATURITY MEASURE

None of the t ratios reached significance at the .05 level when the means in skeletal age for boys in the five somatotype categories were compared. When the highest and lowest 25 percent of the boys in skeletal age were compared, however, the following results were obtained: a significantly greater percentage of boys were advanced than were retarded for the endo-mesomorph category; the reverse was true for the mid-type boys, as there was a significantly greater percentage retarded than advanced in skeletal age.

STRUCTURAL MEASURES

The t ratios for the differences between the means of the structural measures for the various somatotype categories appear in Table 1. Following is a summarization of this table.

1. The means of the endomorphs and the endomesomorphs significantly exceeded the means of the other somatotype categories in body weight, chest girth, upper arm girth, and calf girth. The endomorphs had a greater mean hip width than did all other somatotype categories except the endomesomorphs. In all probability, the heavier flesh folds distributed generally over the bodies of the endomorphs and endomesomorphs account for their greater girth measures. No significant mean difference was found between these two categories and the others in standing height, sitting height, Classification Index I, and lung capacity. For all structural measures, the differences between the means of the endomorphs and the endomesomorphs were not significant.

2. In the original analysis, the means of the ectomorphs were significantly higher than those of the mesomorphs in standing height and leg length. However, these differences were not significant in the supplementary analysis of the 10 and 14 year old boys; thus it is concluded that differences between these categories are due to chance. The mesomorphs had a significantly higher mean upper arm girth and calf girth than did the ectomorphs.

3. For all structural measures in the original analysis, the differences between the means of the mesomorphs and mid-types were not significant. However, in the supplementary analysis, the mesomorphs had significantly higher means in calf girth at both 10 and 14 years and in upper arm girth at 10 years of age.

4. In the original analysis, the means of the ectomorphs were significantly higher than the means of the mid-types in standing height, sitting height, and

TABLE 1.—CONSOLIDATION OF t RATIOS[a] FOR STRUCTURAL MEASURES FOR FIVE SOMATOTYPE CATEGORIES
BOYS 9 THROUGH 15 YEARS OF AGE

Somatotype Categories	Body Weight	Standing Height	Sitting Height	Leg Length	Classif. Index I	Wetzel Physique Channels	Chest Girth	Upper Arm Girth	Calf Girth	Hip Width	Lung Capacity
Endomorph vs. Mesomorph	4.27	1.07	.21	1.54	1.41	7.30	3.35	2.66	2.88	4.97	1.64
Endomorph vs. Ectomorph	4.65	1.12	1.38	1.15	.11	13.24	4.14	4.73	4.49	2.88	1.67
Endomorph vs. Endomesomorph	.96	.01	.87-	.17	.31	.46	.11	.68	.68	1.49	1.50
Endomorph vs. Mid-type	4.84	.77	.29	.82	1.16	5.37	4.15	4.04	3.97	5.30	.68
Mesomorph vs. Ectomorph	.19	2.72[b]	1.89	3.37[b]	1.99[b]	12.22	.80[d]	2.35	1.77[d]	1.98	.19
Mesomorph vs. Endomesomorph	3.05	1.05	1.20	1.21	1.79	10.04	3.29	3.61	3.37	1.88	.07
Mesomorph vs. Mid-type	.27	.54	.06	1.08	.52	4.82[c]	.68	1.37[d]	1.00[d]	.68	1.31
Ectomorph vs. Endomesomorph	3.35	1.11	.37	1.32	.27	18.84	4.03	5.91	4.79	.39	.24
Ectomorph vs. Mid-type	.09	2.82	2.48[b]	2.92[b]	1.87	17.76	.20	1.31	1.00	1.53[d]	1.35
Endomesomorph vs. Mid-type	3.50	.71	1.43	.49	1.60	7.04	4.03	5.29	4.34	1.51	1.16

[a] Underlined t ratios indicate that the second listed somatotype category had the highest mean.
[b] Significance reduced to insignificance at one or both ages (10 and 14 years) upon supplementary analysis.
[c] Significance reversed in favor of other category at one or both ages (10 and 14 years) upon supplementary analysis.
[d] Insignificance changed to signficance at one or both ages (10 and 14 years) upon supplementary analysis.

TABLE 2.—CONSOLIDATION OF t RATIOS[a] FOR GROSS MUSCULAR STRENGTH AND ENDURANCE MEASURES FOR FIVE SOMATOTYPE CATEGORIES OF BOYS 9 THROUGH 15 YEARS OF AGE

Somatotype Categories	Sum of Grips	Back Lift	Leg Lift	Rogers' Arm Strength	McCloy's Arm Strength	Strength Index	Cable-Tension Strength
Endomorph vs. Mesomorphs	.68	1.71	1.27	6.37	.45	1.90	1.59
Endomorph vs. Ectomorph	1.54	.91	1.61	6.01	.51	2.10	1.35
Endomorph vs. Endomesomorph	1.61	1.23	1.51	2.60	1.23	1.76	2.34
Endomorph vs. Mid-type	.06	.22	.56	6.45	.82	1.35	3.48
Mesomorph vs. Ectomorph	.77[b]	3.26[c]	.35[c]	1.37[b]	1.15[b]	.02[b]	.35
Mesomorph vs. Endomesomorph	1.14	3.03	.55	3.21	.86	.09	1.29
Mesomorph vs. Mid-type	.81[b]	2.67[c]	1.25[b]	2.42	1.56[b]	.93[b]	1.46
Ectomorph vs. Endomesomorph	.63	.68	.31	2.19	2.09	.11	1.43
Ectomorph vs. Mid-type	1.89	1.07	1.46	1.08	.41	1.07	2.03
Endomesomorph vs. Mid-type	1.82	1.34	1.30	1.50	2.53	.88	.17

[a] Underlined t ratios indicate that the second listed somatotype category had the highest mean.
[b] Significance changed to insignificance at one or both ages (10 and 14 years) upon supplementary analysis.
[c] Significance reversed in favor of other category at one or both ages (10 and 14 years) upon supplementary analysis.

leg lift. In the supplementary analysis, the ectomorphs were superior to the mid-types in standing height at 10 years of age only. Also, in the supplementary analysis, the ectomorphs had a significantly higher mean hip width at 10 years of age than did the mid-types.

5. High t ratios were obtained for the differences between the five somatotype categories when compared by Wetzel physique channels. These may best be explained through a graphic analysis which showed that the endomorphs and the endo-mesomorphs were predominantly in channels A-4, A-3, and A-2; the mesomorphs and mid-types, in channels A-1, M, and B-1; and the ectomorphs, in channels B-2, B-3, and B-4.

GROSS MUSCULAR STRENGTH AND ENDURANCE MEASURES

A summary of the differences between the means of the gross muscular strength and endurance measures for the five somatotype categories expressed as t ratios is presented in Table 2. Following are the essential features in this table.

1. In the original analysis, no significant difference was found between the sum of grips and leg lift means for the various somatoype categories. In the supplementary analysis, the means of the mesomorph were significantly higher than the means of the mid-types and ectomorphs in sum of grips at 10 years of age, than the means of the mid-types in leg lift at 10 and 14 years, and than the mean of the ectomorphs in leg lift at 14 years. In the original analysis, the back lift of the mesomorphs was significantly lower than the means of the ectomorphs, endomesomorphs, and mid-types. When adjusted for age by comparing the 10 and 14 year old boys, however, the differences in back lift were reversed in favor of the mesomorphs with significant differences between the means.

2. The Rogers' arm strength mean of the endomorphs was significantly lower than the means of the other somatoype categories. The means of the mesomorphs significantly exceeded the means of the endomesomorphs and the mid-types in the original analysis and the means of the mid-types at 10 and 14 years and of the ectomorphs at 14 years of age. The ectomorphs had a significantly higher mean than did the endomesomorphs. For McCloy's arm strength, the mean of the endomesomorphs was significantly higher than the means of the ectomorphs and mid-types in the original analysis; the means of the mesomorphs significantly exceeded the means of the ectomorphs and mid-types at 14 years and of the mid-types at 10 years of age.

3. In the original analysis, the ectomorphs had significantly higher mean Strength Indexes than did the endomorphs, probably due to the greater proportion of older boys in the distribution of ectomorphs. At 10 and 14 years of age, the mesomorphs had significantly higher means than did the ectomorphs and mid-types. When the highest and lowest 25 percents of the boys were compared, a significantly greater percentage of mesomorphs was found in the higher scoring group.

4. In the original analysis, the mean of the endomorphs was significantly lower than the means of the endomesomorphs and mid-types for the cable-

tension strength average; and the mean of mid-types was higher than the mean of the ectomorphs. No significant difference between means for this measure was obtained on the supplementary analysis. When the highest and lowest 25 percents of the boys on the cable-tension tests were compared, significantly greater percentages of mesomorphs and endomesomorphs were found in the upper 25 percent and a significantly greater percentage of ectomorphs was found in the lower 25 percent.

RELATIVE MUSCULAR STRENGTH AND ENDURANCE MEASURES

A summary of the differences between the means of the relative muscular strength and endurance measures for the five somatotype categories expressed as t ratios appears in Table 3. A summarization of this table follows.

1. Sixteen of the 18 boys in the mesomorph category were unable to perform a single pull-up; the mean number of pull-ups for this group was .06,

TABLE 3.—CONSOLIDATION OF t RATIOS[a] FOR RELATIVE MUSCULAR STRENGTH AND ENDURANCE MEASURES FOR FIVE SOMATOTYPE CATEGORIES OF BOYS 9 THROUGH 15 YEARS OF AGE

Somatotype Categories	Pull-Ups	Push-Ups	Physical Fitness Index
Endomorph vs. Mesomorph		7.28	7.50
Endomorph vs. Ectomorph		7.12	9.84
Endomorph vs. Endomesomorph		2.43	3.11
Endomorph vs. Mid-type		8.52	6.52
Mesomorph vs. Ectomorph	2.20	1.88[b]	.88
Mesomorph vs. Endomesomorph	4.42	4.15	4.03
Mesomorph vs. Mid-type	2.80	2.48	2.18
Ectomorph vs. Endomesomorph	2.94	2.88	3.68
Ectomorph vs. Mid-type	.65	.55	1.53
Endomesomorph vs. Mid-type	2.52	2.73	2.62

[a] Underlined t ratios indicate that the second listed somatotype category had the highest mean.
[b] Insignificance changed to significance at 10 and 14 years of age.

which was so low that it was omitted from the table. For the other comparisons, the mesomorphs had significantly higher means than did the endomesomorphs, ectomorphs, and mid-types; and both the ectomorphs and mid-types had significantly higher means than the mean of the endomesomorphs. Much the same results were obtained with the push-up test, performed supporting full body weight on the parallel bars.

2. The Physical Fitness Index means of the endomorphs and the endomesomorphs were significantly lower than the means for the boys in the other somatotype categories; the mean of the endomorphs was significantly lower than the mean of the endomesomorphs. The mean of the mesomorphs was significantly higher than the mean of the mid-types; the difference between the means of the mesomorphs and ectomorphs was not significant. When the highest and lowest 25 percents of the boys on this test were compared, the following results were obtained: significantly greater percentages of endomorphs and endomesomorphs were found in the lower 25 percent; significantly greater percentages of mesomorphs and ectomorphs were found in the upper 25 percent; the mid-types were fairly evenly distributed between these high and low Physical Fitness Index groups.

Conclusions

The characteristics of the five somatotype categories as revealed by this study are presented.

Endomorphs: The endomorphs had greater body weight, chest girth, upper arm girth, calf girth, and hip width than did the mesomorphs, ectomorphs, and mid-types. They were generally found in Wetzel's physique channels A-4, A-3, and A-2. This group was able to perform only a few, if any, pull-ups and push-ups and had lower Rogers' arm strength scores and Physical Fitness Indexes than all other categories. They also had lower cable-tension strength test means than the endomesomorphs and mid-types and lower Strength Indexes than the ectomorphs. (Quite possibly, the Strength Index superiority of the ectomorphs is due to their being generally older; further, the lack of superiority on this test by the mesomorphs could logically be due to their relatively younger ages.)

Endomesomorphs: No difference was found between the endomorphs and the endomesomorphs in the various structural measures; however, the endomesomorphs did show superiority to the endomorphs in number of pull-ups and push-ups, Rogers' arm strength scores, cable-tension strength tests, and Physical Fitness Indexes. This group had greater body weight, chest girth, upper arm girth, and calf girth than did the mesomorphs, ectomorphs, and mid-types. They were generally found in Wetzel's physique channels A-4, A-3, and A-2. The endomesomorphs also had lower Strength Indexes and Rogers' arm strength scores than the ectomorphs; their McCloy's arm strength scores were superior to the ectomorphs and mid-types.

Mesomorphs: The mesomorphs were smaller than the endomorphs in body weight, chest girth, upper arm girth, calf girth, and hip width; the same was

true for comparison with the endomesomorphs, except for hip width. The situation for these structural measures is not conclusive, however, as the mesomorphs generally were younger, a fact which would naturally result in lower means on these tests than would be the case for the generally older endomorphs and endomesomorphs. Compared with the ectomorphs and mid-types, the mesomorphs had larger upper arm and calf girths. Generally, their Wetzel physique channels were A-1, M, and B-1. The mesomorphs had higher means on the following muscular strength and endurance measures than did the ectomorphs and mid-types: back lift, leg lift, Strength Index, pull-ups, push-ups, and both Rogers' and McCloy's arm strength scores. For the Physical Fitness Index, they exceeded the mid-types but not the ectomorphs. As for the structural measures, the comparisons of mesomorphs with endomorphs and endomesomorphs on strength tests was obscured by the differences in age; however, it was clear that the mesomorphs were superior in pull-ups, push-ups, Rogers' arm strength, and Physical Fitness Indexes.

Ectomorphs: The ectomorphs were smaller than the endomorphs and endomesomorphs in body weight, chest girth, upper arm girth, calf girth, and hip width; with the exception of hip width, the ectomorphs were also smaller than the endomesomorphs on these tests. Further, the ectomorphs were smaller than the mesomorphs in chest and calf girths and were larger than the mid-types in hip width. The boys in this category were found largely in Wetzel physique channels B-2, B-3, and B-4. For the muscular strength and endurance measures, the ectomorphs were superior to the endomorphs and endomesomorphs in pull-ups, push-ups, and Physical Fitness Indexes, and to the endomorphs in Strength Index, although this latter superiority was probably due to the fact that the ectomorphic boys were generally older. The ectomorphs were inferior to the mesomorphs in sum of grips, back and leg lifts, Strength Index, pull-ups and push-ups, and Rogers' and McCloy's arm strength scores. The only strength difference between the ectomorphs and mid-types was that the ectomorphs were stronger on the cable-tension tests.

Mid-Types: Although there were a number of exceptions, the mid-types followed somewhat the pattern of the ectomorphs in their comparison with the other somatotype categories. The exceptions were: no difference in chest girth in comparison with mesomorphs, no superiority to endomesomorphs in Rogers' arm strength, and inferiority to mesomorphs in Physical Fitness Index. The only differences noted between the mid-types and the ectomorphs were that the ectomorphs had greater standing height and hip width at ten years of age and the mid-types were stronger on cable-tension strength tests. The mid-types were generally found in Wetzel physique channels A-1, M, and B-1.

The only tests in this study where no mean difference was found between the five somatotype categories were sitting height, leg length, Classification Index I, and lung capacity. For standing height, only one difference was obtained, between the ectomorphs and mid-types. A significantly greater percentage of endomesomorphs were advanced than were retarded in skeletal age; the reverse was true for the mid-type boys.

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Validity of a Football Rating Scale and Its Relationship to Social Integration and Academic Ability

C. C. COWELL
A. H. ISMAIL
Purdue University
Lafayette, Indiana

SUCCESS IN FOOTBALL or any other venture is dependent upon a number of variables. We can predict outcomes only if we know and are able to control the variables of which the outcomes are a function. This study attempts to isolate the most significant items which distinguish "successful" football players from "unsuccessful" players as rated by both football coaches and players. It also indicates factors related to the social integration of a football squad as a social group.

The purpose of this study was to (a) develop a valid and economical rating scale to be used in the selection of the varsity team from among college freshmen, (b) study the social integration of the squad, and (c) determine the interrelationships among physical, social, and academic abilities.

Methods and Procedures

Data were gathered from 45 out of 54 Purdue University freshmen football players during the year 1958-59; nine players who were dropped because of injury were excluded. The data included three measures.

1. *Ratings on football ability.* A revision of Meyer's football playing ability and attitude rating scale was utilized (1). The revised instrument is based on a six-point scale which utilizes the man-to-man rating technique on the following nine variables: condition, aggressiveness, perseverance, team play, attitude toward coaching, ability to play position, blocking, tackling, and football knowledge. Two independent ratings were obtained at the end of the football season: one from every player rating every other player and the other from five football coaches rating each team member independently. In addition, the coaches were asked to group the players into four categories according to football ability. As a result, four groups were established; the first team, the second team, the third team, and the reserves.

2. *Ratings on social acceptance.* Data on social acceptance were achieved through the application of the seven point Cowell Personal Distance Scale (1) at the end of the third week and at the end of the football season.

3. *Scores on academic ability.* Orientation test scores in English and mathematics, obtained from the University Registrar, were used as an index of academic ability.

The data on player to player ratings and coach to player ratings as criterion measures were employed for the derivation of the economical rating scale items, using the Doolittle technique of multiple correlation. The validity of the items was obtained by correlating the scores on the items with the scores assigned by the coaches. The power of discrimination of the items derived was compared with the power of discrimination of the nine football items through the application of the analysis of variance technique.

The social integration of the squad was studied through application of the analysis of variance. In addition, the t test was applied to test the null hypothesis between initial and final social acceptance means.

The interrelationships among football ability, social acceptance, and academic ability were achieved through the Pearson product-moment of correlation technique.

Analysis of Data

Development of a Valid and Economical Rating Scale

The intercorrelations among the nine items and the coaches' rating are presented in Table 1 in matrix form.

TABLE 1.—INTERCORRELATIONS AMONG FOOTBALL PLAYING ABILITY AND ATTITUDE

	1	2	3	4	5	6	7	8	9	0[a]
1. Condition		.771	.737	.379	.577	.769	.624	.475	.745	.601
2. Aggressiveness			.840	.598	.645	.788	.816	.733	.801	.646
3. Perseverance				.682	.793	.733	.639	.528	.711	.659
4. Team Play					.806	.355	.482	.435	.357	.374
5. Attitude Toward Coaching						.580	.464	.358	.498	.656
6. Playing Position							.807	.670	.842	.708
7. Blocking								.926	.772	.554
8. Tackling									.604	.482
9. Football Knowledge										.608

[a] 0 = criterion score (coaches' ratings).

Utilizing the Doolittle technique of multiple correlation, items which yielded no importance according to their beta weights were dropped one at a time. Two out of nine items were considered important in rating football ability. The two items were "attitude toward coaching" and "ability to play position." Studying these two items, two composite word pictures of the attributes of the "successful" players were made possible, as follows:

Attitudes toward coaching: Listens to coaches at all times; carries out their instructions; always plays for the team to win; never thinks of his own glory; works constantly to improve fundamentals and condition; very aggressive; always tries hard; never quits.

Playing his position: Knows every duty well; has first team ability; analyzes changes in defensive and offensive situations quickly; blocks with skill, accuracy, and body control; aggressive and has football "know how."

The data pertaining to the analysis of these two items are presented in Table 2. The multiple correlation was .770, which yielded .593 percent of the total variance. The validity coefficient for the two-item rating scale was calculated by correlating the scores on the two items with the criterion measure and found to be .711.

TABLE 2.—ANALYSIS OF THE TWO ITEM CRITERIA

Items	Beta Weights	Percent Contribution	R^2	R
Attitude toward coaching	.370	.410	.593	.770
Playing position	.494	.590		

Utilizing the analysis of variance technique, the power of discrimination of the two-item rating scale was compared with the original nine-item scale. The difference among the four groups (the first team, the second team, the third team, and the reserves) was investigated by testing the null hypothesis as

TABLE 3.—RESULTS OF THE APPLICATION OF THE F TEST
(the nine-item scale)

Sources of Variations	S.S.	d.f.	m.s.	F
Between groups	.573	3	.191	3.351
Within groups	2.355	41	.057	
Total	2.9275	44		

shown in Table 3, the F value was 3.351, which is significant at the 5 percent level of confidence. The null hypothesis was rejected at better than the 5 percent level of confidence, and therefore it may be concluded that the four teams were not from the same population in terms of football ability.

Rejection of the null hypothesis might be due to difference in means or variances or both. The Bartlett test of homogeneity of variance was applied and with the proper degrees of freedom, the value of the chi square obtained was .009, which is much smaller than the needed value for significance. Hence, the null hypothesis was held tenable. It may be concluded that the homogeneity of variance was present and the t test could be applied to test the difference between means taken two at a time. From the results of the application of the t test, as shown in Table 4, it may be concluded that there were significant differences in football ability between the means of the first and third teams and between the first and fourth (reserves) teams in favor of the first team.

The statistical procedures reported in Table 3 were repeated utilizing the two-item criteria instead of the nine-item scale, to find out whether or not the two-item rating scale was able to discriminate in the same fashion as the

TABLE 4.—RESULTS OF THE APPLICATION OF THE *t* TEST
(nine-item scale)

Teams	d.f.	Observed diff.	Diff. needed for significance	Significant at the 5% L. C.
1-2	20	.085	.196	No
1-3	19	.267	.237	Yes
1-4	22	.265	.204	Yes
2-3	19	.183	.221	No
2-4	22	.180	.185	No
3-4	21	.005	.227	No

TABLE 5.—RESULTS OF THE APPLICATION OF THE F TEST
(the two-item criteria)

Sources of Variations	S.S.	d.f.	M.S.	F
Between groups	.825	3	.275	5.139
Within groups	2.184	41	.053	
Total	3.0086	44		

nine-item instrument. The results are presented in Table 5. The F value was 5.189, significant beyond the 1 percent level of confidence. The null hypothesis was rejected, and therefore, it may be concluded that the four teams were not from the same population in terms of football ability.

Investigating the homogeneity of variance among the four teams showed that the homogeneity of variance was present from group to group. The t test was applied for testing the difference between means taken two at a

TABLE 6.—RESULTS OF THE APPLICATION OF THE *t* TEST
(two-item criteria)

Teams	d.f.	Observed diff.	Diff. needed for significance	Significant at the 5% level
1-2	20	.141	.184	No
1-3	19	.284	.236	Yes
1-4	22	.346	.183	Yes
2-3	19	.144	.230	No
2-4	22	.205	.176	Yes
3-4	21	.061	.228	No

time, and the results are presented in Table 6. It may be concluded that there were significant differences in football ability between the means of the first and third teams in favor of the first team. Furthermore, a significant difference was found between the second and the fourth teams in favor of the second team.

The results obtained from application of the F test and the t test on the nine-item and the two-item instruments were compared. It was concluded that the two-item instrument has as high discrimination power in terms of football ability as the nine-item scale. Consequently, further validation was demonstrated pertaining to the validity of the two-item rating scale.

TABLE 7.—RESULTS OF THE FIRST AND SECOND APPLICATION OF THE COWELL PERSONAL DISTANCE SCALE

Source of Variations	S.S.	d.f.	M.S.	F	Significant at the 5% level
First Application					
Between groups	279.661	3	93.204[a]	1.033	No
Within groups	3698.967	41	90.219		
Total	3978.578	44			
Second Application					
Between groups	30.670	3	10.223[a]	.097	No
Within groups	4456.970	41	108.707		
Total	4487.640	44			

[a] F = 93.204/10.223 = 9.117

STUDY OF THE SOCIAL INTEGRATION OF THE SQUAD

The analysis of variance technique was applied to the data collected on the first and second applications of the Cowell Personal Distance Scale. The null hypothesis pertaining to the social integration among the four teams was tested. The results are presented in Table 7. The F values for the first and second application of the Cowell Personal Distance Scale were too small to be significant at the 5 percent level. Hence, the null hypothesis for each application was held tenable. It might be concluded that the four teams were from the same population in terms of social integration during the first and second application of the scale. However, the mean square for the between groups during the second application of the scale decreased greatly, which resulted in a significant F between the two between groups variances. It may be concluded that the squad as a whole experienced a significant change in terms of social integration by the end of the football season; the squad made a significant gain in "togetherness."

The differences between the initial and final means for the four teams and the squad as a whole were investigated. The results are presented in Table 8.

TABLE 8.—RESULTS OF THE APPLICATION OF THE t TEST

Teams	First Application Means[a]	Second Application Means	d.f.	Obtained t	t Value for Significance	Significant at the 5% L.C.
First Team	51.55	52.55	20	.203	2.086	No
Second Team	46.09	52.64	20	1.538	2.086	No
Third Team	45.70	52.00	18	1.795	2.101	No
Reserves	45.54	54.15	24	2.219	2.064	Yes
Whole Squad	2.794	2.573	89	2.725	1.989	Yes

[a] Team scores represent T scores. The squad score represents the raw score. Decrease in personal distance scores represents increased social integration.

No significant differences existed between the means of the first and second applications of the Cowell Personal Distance Scale when administered to the first, the second, and the third teams independently. A significant difference

was found between the means of the first and second applications of the Cowell Personal Distance Scale when administered to the reserves and to the squad as a whole. Hence, it could be concluded that the players who constituted the reserve team as well as the squad as a whole experienced significant changes in terms of social integration. In other words, the reserve team and the squad as a whole were significantly more socially integrated at the end of the football season than at the beginning.

Rivalry for the specific positions might be a factor for obtaining the above findings in personal distance means among the first, second, and third teams. The improvement in personal distance among the "rejectees" (reserves) perhaps indicates that "misery seeks company."

Interrelationships among Physical, Social, and Academic Abilities

The correlation coefficients between football and academic abilities, obtained by utilizing the Pearsonian r, and presented in Table 9, were low and positive. Testing the null hypothesis, it was found that the coefficients were not significant, and it could be concluded that no relationship existed between football and academic abilities.

Following the same statistical procedures, the correlation coefficients between football ability and social acceptance were obtained. The data are shown in Table 10. The coefficients of correlation were positive and medium. Testing the null hypothesis, it was found that the coefficients were significant at the 5 percent level of confidence, and it could be concluded that a significant relationship existed between football ability and social acceptance.

TABLE 9.—THE CORRELATION COEFFICIENTS BETWEEN FOOTBALL AND ACADEMIC ABILITIES

Ratings on Football Ability	Academic Factor	r
Blocking	Composite scores on English and Mathematics	.018
Team play	Composite scores on English and Mathematics	.038
Condition	Composite scores on English and Mathematics	.040
Playing position	Composite scores on English and Mathematics	.051
Perseverence	Composite scores on English and Mathematics	.097
Aggressiveness	Composite scores on English and Mathematics	.179
Football knowledge	Composite scores on English and Mathematics	.193
Tackling	Composite scores on English and Mathematics	.237
Attitude toward coaching	Composite scores on English and Mathematics	.380
Composite scores of the above items	Composite scores on English and Mathematics	.103

TABLE 10.—CORRELATION COEFFICIENTS BETWEEN FOOTBALL ABILITY (9 ITEMS) AND SOCIAL ACCEPTANCE

Ratings on Football Ability	Ratings on Social Acceptance	r
The nine-item scale instrument	First application of the Cowell Personal Distance Scale	.688
The nine-item scale instrument	Second application of the Cowell Personal Distance Scale	.783

Conclusions

Within the limitations of this study, the following conclusions seem justified.

1. The two-item scale ("attitude toward coaching" and "playing his position"), when a man-to-man rating technique is employed, is recommended for selecting the varsity football players from among the freshmen squad.
2. The social integration of the football squad increases according to the length of time the players play together. The social integration of the football squad appears to be affected by intense competition for places on the team.
3. While football and academic abilities are independent, football ability and social acceptance are related.

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(Submitted November 10, 1960)

Electromyographic Observations of the Effects of Static Stretching upon Muscular Distress

HERBERT A. DE VRIES
Long Beach State College
Long Beach 4, California

Abstract

Equipment was assembled to record resting muscle action potentials electromyographically at a very high sensitivity level (10 microvolts per cm. of needle deflection). Electromyograms for seven subjects having chronic muscular involvement of the shin splint type were recorded before and after static stretching procedure was administered. In six of the seven subjects muscle action potentials were markedly reduced after the stretching procedure while in one subject an increase was observed. Of the six subjects who showed lowered electromyograms those who had pain symptoms at the time of experimentation also showed some measure of symptomatic relief.

THE PREVAILING OPINIONS in the literature regarding causation of muscular soreness seem to be based largely upon the work done by Hough (6, 7) in the latter part of the nineteenth century. In general, two types of muscle soreness have been suggested: (a) an early and general soreness occurring usually within four to eight hours, which disappears rapidly, and (b) a localized soreness, sometimes called a myositis, which usually appears eight to twenty-four hours after unaccustomed exercise and may persist for several days. The first type of soreness was attributed to the diffusible end products of metabolism acting upon pain receptors. The second type was thought to arise as the result of torn muscle fibers and/or connective tissues.

In a recent study (5), it was suggested by the writer that it might be considered somewhat unreasonable to postulate structural damage to a tissue caused by the very function for which it is specifically differentiated. A new working hypothesis was proposed: Muscular distress following unaccustomed exercise is caused at least in part by tonic muscle spasm. A corollary to this hypothesis was also stated: If muscular distress following unaccustomed exercise is caused in any way by tonic muscle spasm then some degree of prevention should be brought about through the use of a static stretch similar in principle to that used commonly by swimmers to relieve cramp in the calf muscles.

This hypothesis was tested under controlled experimental conditions, and significantly lesser magnitudes of muscular distress were observed after static stretching procedures were administered. It was realized, however, that even though stretching reduced muscle soreness no clear cut causal relationship between tonic muscle spasm and muscle distress had been demonstrated. It

was concluded that only permissive support was provided for the hypothesis. Further testing of the hypothesis seemed to demand electromyographic evidence. It is the purpose of this paper to describe a method for the recording of extremely low level muscle action potentials and to cite seven case studies of severe muscular distress in athletes in the effort to test further the hypothesis regarding the causation of muscular distress.

Electromyographic equipment commonly used clinically and in medical and physical therapy research seems to have been developed primarily for good wave form reproduction rather than extreme sensitivity. The sensitivity of such equipment seems to be of the order of 30 to 40 microvolts per cm. deflection (3, 4). Since this sensitivity was not considered sufficient for differentiation of low level resting muscle action potentials for the purpose of this study, equipment was assembled which attained a sensitivity of 10 microvolts per cm. deflection.[1] The frequency response was found to be from 0.2 to 50 cycles per second as measured by the 3 decibel point.

Methodology

Apparatus

A screen room to house the subject was built of copper window screen around a wooden frame, 5 feet by 8 feet and ceiling height, with ceiling and floor also covered by copper screen. This was found necessary in order to work at extremely low levels of muscle action potential without interference from stray 60 cycle alternating current.

An Edin model 220 electrocardiograph was used as the recording device. Jacobson (8) showed the necessity of sensitivity on the order of 1 cm = 1 microvolt in order to demonstrate complete muscle relaxation, and this was the objective for our apparatus. To arrive at this sensitivity, the electrocardiograph was preceded by a Tektronix model 122 voltage amplifier with gains of 100 and 1000. The electrocardiograph is usually calibrated to provide a deflection of 1 cm. per millivolt of potential at the electrodes. Thus, when preceded by the preamplifier, set at a gain of 100 to 1, a calibration of 1 mm. deflection for 1 microvolt is the result. This calibration seemed to be the most discriminatory for the purpose of recording muscle action potentials when a limb was at rest and relaxed, and it was used throughout for all of the case studies reported.

Two electrodes were used. One was a typical EKG electrode consisting of a flat plate 4 by 6 cm. held in place by a rubber band 3 cm. wide which encircled the limb. The other was a cup electrode 15 mm. in diameter, held in place by an evacuated rubber bulb of ⅛ ounce capacity. All leads from the electrodes to the preamplifier were electrically shielded as was the preamplifier.

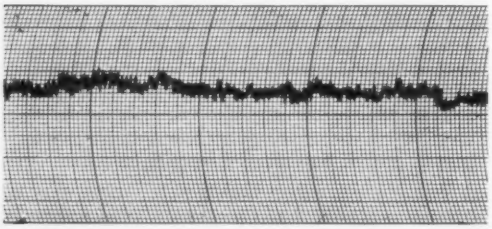
[1] The writer wishes to acknowledge his indebtedness to the Division of Engineering at Long Beach State College for the use of equipment that would not otherwise have been available and most especially to Donald Elliott Robinson, whose collaboration in the development of the electronic equipment helped to make this study possible.

Since the magnitude of the muscle action potentials was of critical significance it was decided to set up calibration devices which would assure high degrees of reliability and objectivity. A Hewlett Packard model 202-A low frequency function generator was procured to furnish a standard signal with sine wave characteristics at a known frequency and amplitude. The standard signal from this device was then impressed upon a type 546 C General Radio Company Audio Frequency Microvolter whose output could be accurately set at 1, 10, or 100 microvolts, root mean square. The output from the audio frequency microvolter was used to calibrate the entire system by introducing this signal at the electrodes and measuring the frequency and amplitude recorded by the electrocardiograph.

Limitations

Under practical experimental conditions, it seemed impossible to get recordings below 3–5 microvolts, which represented the basic noise level inherent in this equipment (Figure I). However, this seemed to pose no great problems as the comparisons made in this study were all well above this basic noise level. Only on very infrequent occasions was any subject able to relax well enough to approach the basic noise level.

The frequency response was found to be from 0.2 to 50 cycles as measured by the 3 decibel point. However, with surface electrodes any recording of muscle action potentials was considered to be a random sampling of the firing of many motor units, and the frequency response was probably not too important since the sum total magnitude of electrical activity was the factor under investigation in this study. Also, Basmajian (1) states that the nerve impulses innervating muscle fibers have varying frequencies in different axons ranging up to 50 per second.



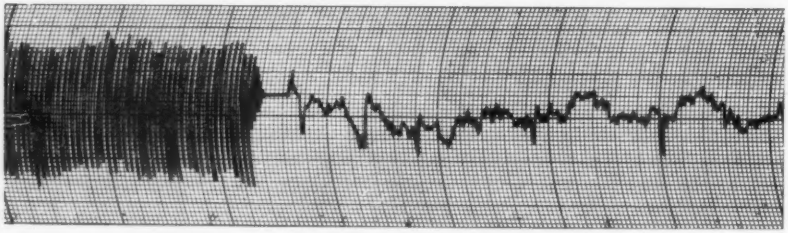


Figure I. Basic noise level and calibration of equipment. At left, typical noise level with electrodes shorted out. Below, typical calibration at 20 c.p.s.

Subjects

Subjects were students at Long Beach State College. Coaches and the athletic trainer were asked to refer students who exhibited severe muscle distress problems, such as shin splints.

Testing Procedure

When a subject presented himself for testing the procedure was as follows:

1. All of the electronic equipment was turned on and allowed to warm up for 5 minutes to assure proper operating temperatures and consequent stability of response.
2. The basic noise level of the entire equipment was checked by shorting the electrodes to the grounded cage and recording 10 seconds. No tests were made if this basic noise level was above 5 microvolts peak to peak in amplitude.
3. The equipment was calibrated at a signal amplitude of 28 microvolts peak to peak = deflection of 28 mm. (10 microvolts RMS at the signal generator = approximately 28 microvolts peak to peak at the recorder).
4. The subject was seated in a tablet arm chair in the screen room, and approximately one-half cc. of EKG SOL, a cream for electrocardiography, was rubbed into the subject's skin in an area of several square inches where the electrodes were to be applied.
5. The cup electrode was applied over the point of greatest soreness. The plate electrode was applied at an indifferent point such as just above the medial malleolus in the case of the lower leg involvement. In all cases, a ball point tracing was made around each electrode so that identical placement could be made for retrials.
6. The subject was now asked to assume a comfortable relaxed position with the weight of the body part to be tested supported by the tablet arm of the chair in the case of the arm or by the floor in the case of the leg. This position was noted and closely approximated in all retrials.
7. The subject was tested for obvious tensions by the investigator who moved the body part to be tested, observing and correcting any efforts on the part of the subject to assist, resist, position, or persevere during the movements.
8. Muscle action potentials were recorded for approximately 30 seconds. If the first recording showed any tendency to change in a downward direction then further 30 second sequences were run until a stabilized reading was obtained.

All retests were made in exactly the same manner.

Stretching Procedure

In all cases the stretching procedure administered was of the static stretch type in which a fixed position was assumed and held for periods of 1–3 minutes at a time. This position was so devised that the body weight locked the limb in question into a position which assured holding the muscle involved at its greatest possible length. For tibial involvement, this position was achieved by kneeling on both knees on a mat with feet plantar flexed and then raising the knees from the mat as high as possible by bending backward and supporting the weight of the upper body on the hands behind the subject. This position was then held without movement for the required period of time. Wrist flexor involvement was accomplished by having the subject stand slightly more than arms distance from and facing a wall, then placing the hand flat on the wall with the middle finger pointing upward. He then rested his weight against this hand with the arm extended and maintained the hand as far downward on the wall as possible.

Findings

Cases #1 and 2 (Figures II and III). These two cases serve to illustrate the fact that exercise of even short duration and moderate resistance does result in measurable differences of resting muscle activity level as measured by electromyographic recordings of muscle action potentials. In neither of these cases did soreness ensue. This evidence is not intended to contradict in any way the evidence offered by Basmajian (2) and others that resting muscle tissue can be completely inactive and can achieve electrical silence. However, it was found to be in agreement with Jacobson (8) that when highly sensitive equipment is used, training is necessary to achieve complete electrical silence.

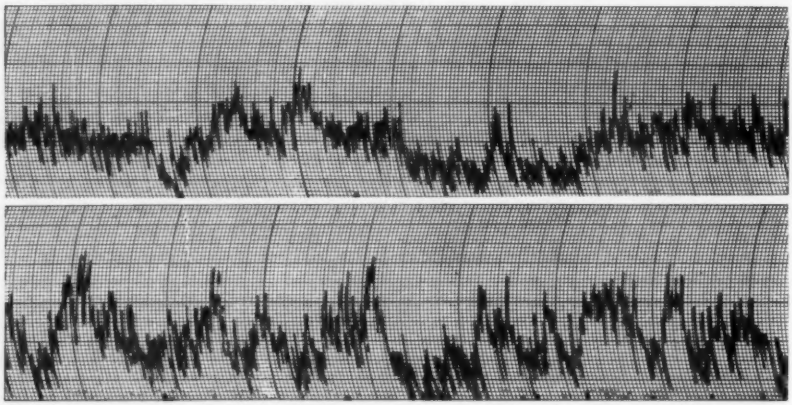


FIGURE II. Case #1 (age 42). Top, before exercise (relaxed). Bottom, after exercise (relaxed, identical position). No history. Demonstration of residual muscle tension before and after curling 22.5 lb. dumbbell 1 × 10 repetitions. *Electrode placement*—right arm cup elec. on volar aspect of biceps brachii approx. 2" above crease of elbow joint. EKG plate elect. palmar aspect of wrist.

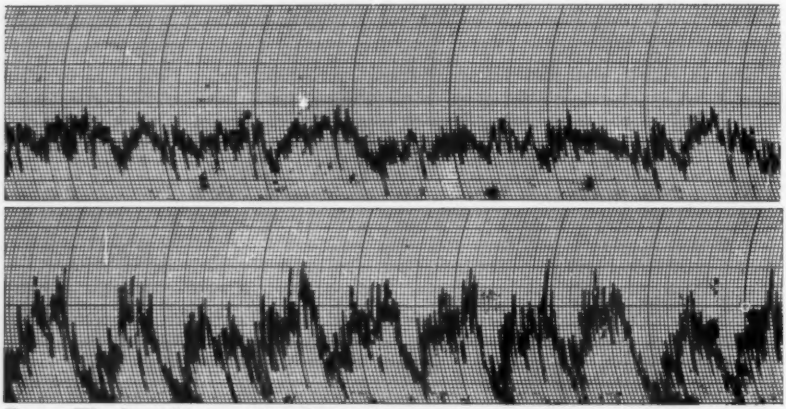


FIGURE III. Case #2 (age 31). Top, before exercise (relaxed). Bottom, after exercise (relaxed, identical position). No history, no symptoms. Demonstration of residual muscle tension before and after curling 12.5 lb. dumbbell 2 × 10 repetitions. *Electrode placement*—same as Case #1.

Case #3 (Figure IV). This subject was referred from the track team because of frequently recurring shin splints. Questioning and palpation indicated involvement of the tibialis anterior. Stretching resulted in lowered muscle action potential level and also partial symptomatic relief. The subject seemed able to control the shin splint problem throughout the 1960 track season by use of stretching techniques both before and after participating in his event.

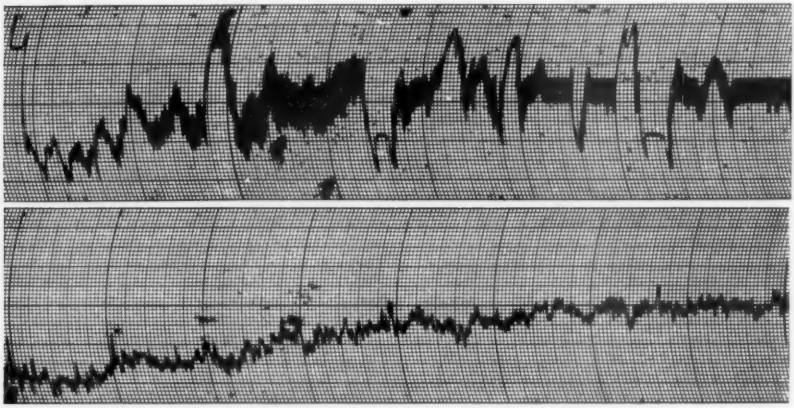


FIGURE IV. Case #3 (age 20). Top, before stretching. Bottom, after stretching. Hurdler with recurring symptoms of shin splints of moderate degree. *Electrode placement*—left leg cup elect. on ant. aspect approx. 4" below tibial tubercle. EKG plate electrode on medial aspect of lower left leg approx. 4" int. malleolus. *Exercise*—2-min. static stretch done twice with 1-min. rest period between. *Results*—lower EMG reading; also partial symptomatic relief.

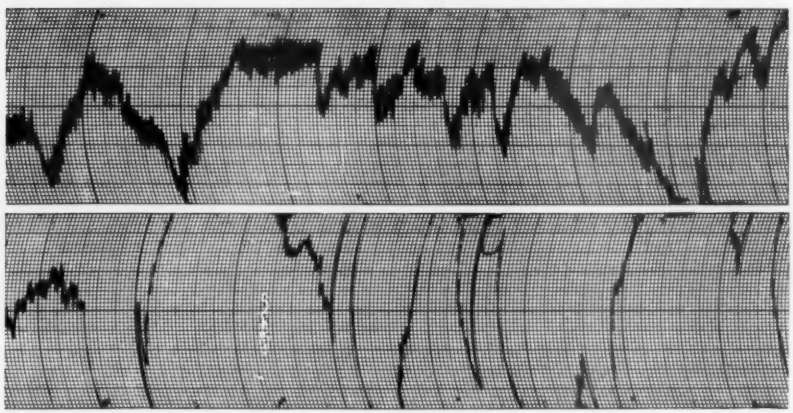


FIGURE V. Case #4 (age 23). Top, before stretching. Bottom, after stretching. Track athlete with long history of chronic problem with shin splints, slight symptoms. *Electrode placement*—same as Case #3. *Exercise*—two 1-min. periods of static stretch separated by 1-min. rest period. *Results*—marked rise in EMG readings.

Case #4 (Figure V). This subject had a history of frequently recurring attacks of the shin splint problem of such severity that he had given up track activity. As in case #3, the tibialis anterior seemed to be the focal point for the pain symptoms. Only slight symptoms of pain were present at the time of testing. The electromyographic record before stretching showed a somewhat elevated level of muscle activity. After two one-minute periods of static stretching a greatly increased level of muscle activity was found in the after electromyogram. To interpret properly the magnitude of the muscle action potential activity after stretching for this subject, one must realize that the electrocardiograph used had a limiting device which prevented excursions of the needle beyond full scale deflection. This means that wherever the tracing remains at the top or bottom of the graph a potential greater than 25 microvolts was present at the electrodes. In this subject stretching also increased the magnitude of the pain to a small degree.

Case #5 (Figure VI). This subject was another track athlete who had given up running because of the constantly recurring shin splint problem. Although no symptoms were present at the time of this experiment, it was considered of interest to determine the subject's reaction to stretching of the muscles which chronically reacted with pain symptoms to hard competitive running. If we accept Hough's hypothesis of pain due to tearing of muscle tissue then an increased level of muscle activity might be expected as the result of stretching due to reflex stimulation. This was not the case. On the contrary, a markedly lowered muscle activity level was observed after the stretching procedure.

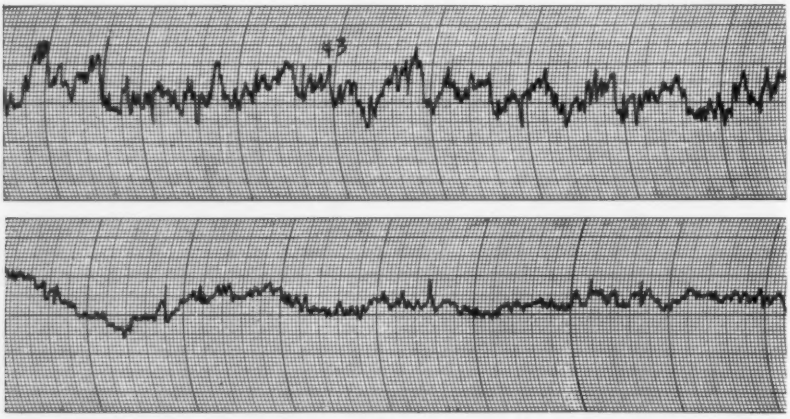


FIGURE VI. Case #5. Top, before stretching. Bottom, after stretching. Track athlete with long history of chronic shin splint problem, no symptoms under laboratory conditions. *Electrode placement*—left leg cup elect. on ant. aspect approx. 4" below tibial tubercle. Plate elect. on medial aspect of lower left leg approx. 4" above int. malleolus. Exercise—1-min. static stretch done twice with 1-min. rest period between. Results—markedly lowered EMG readings.

Case #6 (Figure VII). The subject presented himself to the investigator immediately following a gymnastics meet in which he had competed on the side horse. He complained of what he termed "shin splints" of the arm. Palpation indicated moderately severe involvement of the wrist flexor muscles seemingly centered in the flexor digitorum profundus. The before stretching electromyogram showed considerably more activity than the usual resting muscle. After stretching for two one-minute periods, the subject reported considerable relief from his symptoms and the electromyogram recorded considerably less activity.

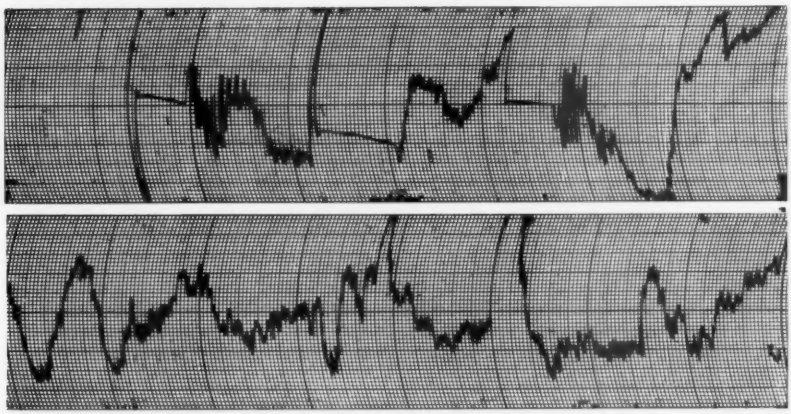


FIGURE VII. Case #6 (age 20). Top, before stretching. Bottom, after stretching. Severe "shin splints" of the left arm following gymnastics work. *Electrode placement*—cup electrode on medial aspect of left forearm approx. 3″ distal to medial epidcondyle of humerus. Plate elect. on volar surface of left wrist. *Exercise*—1-min. static stretching of wrist flexors done twice, with 1-min. rest between. *Results*—lower EMG readings; also partial symptomatic relief.

Case #7 (Figure VIII). This subject had been involved in the same gymnastic meet and complained of essentially the same muscular involvement as Case #6. The onset of the pain symptoms, reported as severe, had occurred immediately after holding a crucifix position on the rings. The before stretching electromyogram indicated a markedly overactive muscle. After stretching of the wrist flexor group, this subject reported complete relief and the after stretching electromyogram seems to indicate a close to normal level of activity.

Case #8 (Figure IX). This was another track athlete who had frequently recurring shin splints to a moderate degree, but in whom no symptoms were elicited at the time of the experiment. Again static stretching resulted in an electromyogram showing lowered activity, rather than the increased activity which might be expected if torn muscle tissue were the cause for the symptoms. This subject also reported some degree of relief over a period of three weeks of using this stretching procedure before and after participation.

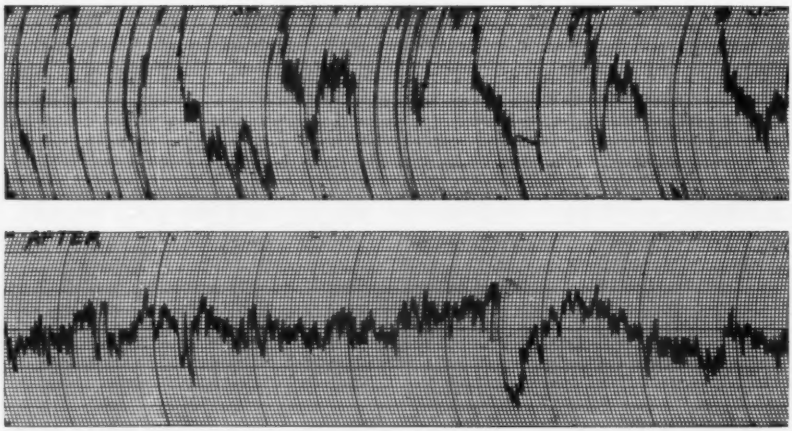


FIGURE VIII. Case #7 (age 22). Top, before stretching. Bottom, after stretching. Severe pain localized in the area of the flexor digitorum profundus, acute symptoms. *Electrode placement*—cup elect. on medial aspect of left forearm approx. 3″ distal to medial epicondyle of humerus. Plate electrode on volar surface of left wrist. *Exercise*—1-min. static stretching of wrist flexors done twice, 1-min. rest between. *Results*—markedly lower EMG readings, no pain.

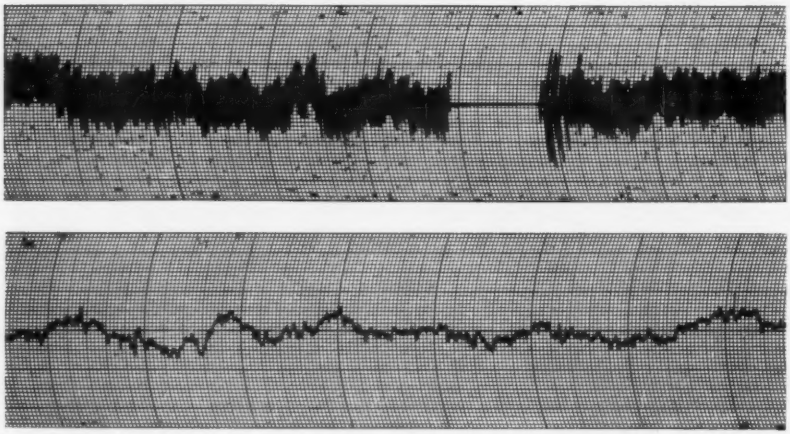


FIGURE IX. Case #8 (age 22). Track athlete with recurring symptoms of moderate shin splints, none at time of experiment. *Electrode placement*—left leg cup elect. on ant. aspect approx. 4″ below tibial tubercle. EKG plate electrode medial aspect of lower left leg approx. 4″ above int. malleolus. *Exercise*—2-min. static stretch down twice with 1-min. rest period between. *Results*—lower EMG reading; symptomatic relief over period of several weeks.

Case #9 (Figure X). This subject was a gymnast whose specialty was the side horse event. He reported chronically recurring pain in the wrist flexor group following workouts, which seemed to be localized largely in the flexor carpi ulnaris. The before stretching electromyogram showed a raised level of muscular activity. The after stretching electromyogram indicated an essentially normal electromyogram which approached the basic noise level of the equipment. The subject reported immediate but partial relief of the symptoms after stretching.

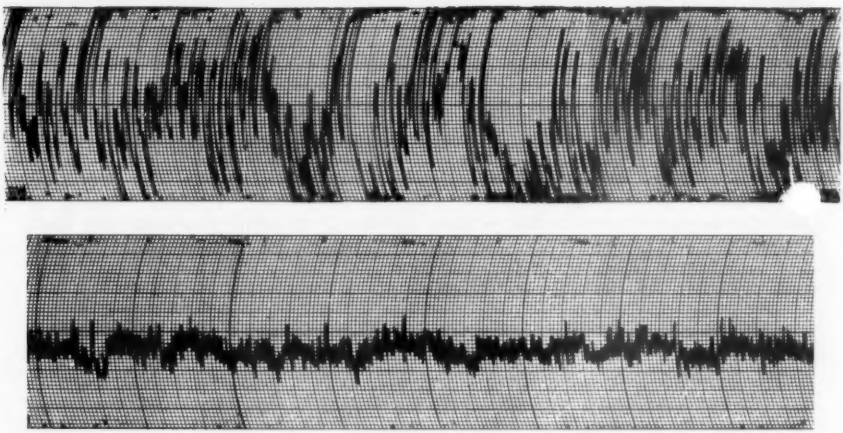


FIGURE X. Case #9 (age 24). Top, before stretching. Bottom, after stretching. Chronic recurring pain after gymnastic work, acute symptoms in wrist flexor group. *Electrode placement*—cup elect. approx. 4" distal to medial epicondyle and EKG plate elect. on volar aspect of wrist, both on right arm. *Exercise*—3-min. static stretching of right wrist flexors, 1-min. rest period; repeat for 2-min. *Results*—markedly lowered EMG; partial symptomatic relief.

Figure XI demonstrated the reaction of a normal unexercised muscle to static stretching.[2] Many such recordings have been made by the writer as controls and Figure XI is typical not only of the lack of reaction by normal unexercised muscle to static stretching but also of placement-replacement of electrodes to test for differences due to apprehensive states.

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[2] It may be observed that the basic noise level of the electromyographic equipment in Figure XI is of a lower magnitude (e.g., 1-2 microvolts) than that illustrated in Figure I. The equipment used in Figure XI is an improved version in which the preamplifier has been transistorized. The sensitivity and the frequency response have remained essentially the same while the basic noise level has been lowered in the equipment currently in use for the ongoing research studies in the area of muscular distress at the Long Beach State College Physical Education Laboratory.

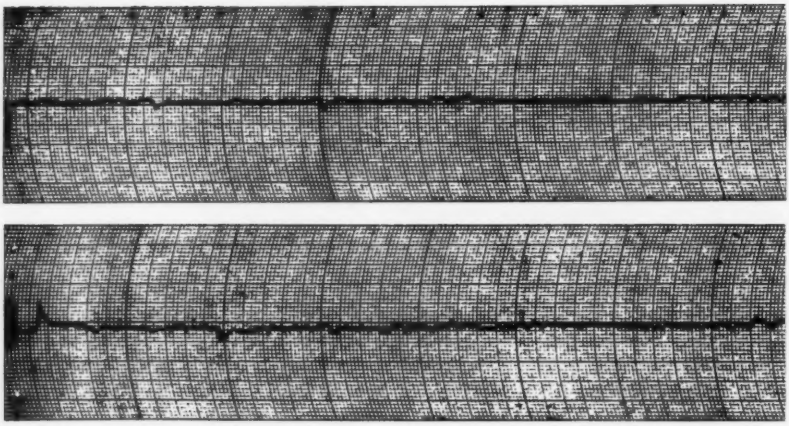

FIGURE XI. Normal subject (age 29). Top, before stretching. Bottom, after stretching. No symptoms, no soreness, no exercise preceding observation. Tracings presented as typical of normal subject reaction to static stretching. *Electrode placement*—cup elect. approx. 4" distal to medial epicondyle and EKG plate elect. on volar aspect of wrist, both on left arm. Exercise—1-min. static stretching of wrist flexors done twice, 1-min. rest between. *Results*—no observable change.

Discussion

The evidence presented in this and a prior (5) study does not seem to support the hypothesis first presented by Hough, which postulates structural damage to muscular tissue as the cause of muscular distress after exercise. If structural damage were indeed the causative factor for muscular soreness then stretching the affected muscle might be expected to flood the nervous system with sensory stimuli which would have as its logical consequence a rise in reflex motor activity especially in the muscle involved. This was not found to be the case except in one subject, case #4, where the symptoms were severe to the point of incapacitation.

The hypothesis set up by the author, that "muscular distress following unaccustomed exercise is caused at least in part by tonic muscle spasm," has received some support. The following experimental evidence has been demonstrated: (a) a higher residual level of muscle activity following exercise, (b) a relationship between pain symptoms and the recorded level of muscle activity, (c) a partial to complete relief of symptoms following stretching, and (d) a decreased level of residual muscle activity as the result of stretching the involved muscle.

The one case which reacted to stretching by an increased muscle activity could very well have been an atypical case in which structural damage did occur. Certainly nothing in this report is meant to be construed as precluding the possibility of tearing or rupturing of muscle fibers in a violent movement followed by severe symptoms. The main concern of this study and the

one which preceded it was rather with the more common symptoms following exercise which could hardly be termed violent.

Conclusion and Implications

There is insufficient evidence, as yet, to warrant any sweeping generalizations. However, the experimental evidence so far provided would seem to support the hypothesis that muscular distress following unaccustomed exercise is caused at least in part by tonic muscle spasm.

On the basis of the experimental evidence provided in this and the earlier study (5), the practical implications for our profession can be stated as follows:

1. Under certain conditions, the use of static stretching technique following unaccustomed exercise seems to provide some measure of prevention of ensuing muscular distress.

2. Static stretching seems to provide a useful technique for the relief of chronic muscular distress such as shin splints in some athletes.

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(Submitted November 15, 1960)

Origins of Contemporary Sports

MARVIN H. EYLER
University of Maryland
College Park, Maryland

Abstract

The central purpose of this study was to determine the origin of sports extant in English-speaking countries. The method of research utilized was principally historical-bibliographical and was concerned with the collection, criticism, and synthesis of source material in an effort to establish past actuality. Specific documentary evidence concerning the date, place, and significant circumstances associated with the origins of 95 sports was synthesized. In most instances, establishing the date and place of origin was possible. Often, however, determining the personnel and circumstances connected with the origins was not possible. Charts show the dates of the origins chronologically, the origins attributed to various countries, and the activities from which the 95 sports evolved.

APPROXIMATELY 12 YEARS AGO certain graduate requirements led the writer to explore, quite superficially at first, the beginnings of some of our more popular and universally practiced sports. It soon became evident that the sources for such information were widely diverse and in many instances not generally known or readily available. By diversity of sources is meant the immense range of extant artifacts and documents which reveal information relative to the origins of sports. It also became quite evident that within the literature there was considerable variance, confusion, and, in some instances, contradiction.

Purpose

The purpose of the original study,[1] therefore, was to determine, as far as was practicable, the origins of sports. More specifically, the study attempted to specify: (a) the date of origin or the earliest reference in the literature when a date could not be ascertained with any real degree of accuracy, (b) the geographic location of the sport's origin, and (c) certain activities from which the sports reported upon evolved.

Originally the writer intended to study and report upon the origins of all currently practiced sports in English-speaking countries. However, it soon became evident that this could not be accomplished at present due to the immensity of the problem, the unavailability of credible sources, and the factor of time. After an extensive search for evidence, the material collected was collated, analyzed, and synthesized. As a result, information relative to the origins of 95 of the sports extant in English-speaking countries are being reported. This information is based on the resources available in the New York Public Library, the Library of Congress, the University of

[1] The study was a doctoral dissertation completed under the guidance of S. C. Staley, dean, College of Physical Education, University of Illinois, Urbana.

Illinois Library, the Huntington Library, and, in film form, the Bodleian Library and the British Museum.

Limitations of the Study

In considering the "firsts" in any area of knowledge, problems immediately become apparent. In a study of the origin of sports, problems pertain to those sports which were previously a method of protection, a mean of livelihood, or a preparation for military pursuits. A point had to be determined when an activity ceased to be chiefly utilitarian and became primarily a sport or an amusement. Such sporting activities as angling, archery, boxing, swimming, and wrestling fall into these categories.

Another problem is the question of how far back one should go in searching for the genuine origin. To be specific, when did such activities as rounders, one-o-cat, and town ball coalesce into the sport of baseball? It was obvious that there could be no set rule to follow in synthesizing such material; the solution depended upon the circumstances of each individual case. The general rule followed was that for highly controversial origins, a date was designated only at the point in the sport's development when the sport became easily recognizable with the modern concept of method of play, and/or when the sport was governed by a body of recognizable rules.

Certain limitations were imposed on the scope of the study. Sports that are practiced largely or exclusively in non-English-speaking countries were eliminated except for cases in which mention of such a sport was necessary to a full understanding. For example, a statement explaining the relationship of *jeu de paume* and the origin of tennis is relevant. Extinct sports such as bull, bear, and badger baiting; jousting; cudgeling; and tournament were not included. Children's play activities, that is, games or sports such as hopscotch, blindman's buff, and battledore and shuttlecock, were excluded. The study did not include games or pastimes which require little or no gross muscular movements, such as card games, chess, and checkers. Sport-work activities or contests such as woodchopping, plowing, axethrowing, and tree climbing were not investigated. Excluded also were miscellaneous sporting activities such as dog and horse shows. Omitted were some sports currently practiced in English-speaking countries for which there was insufficient source material available to warrant a valid statement. Finally, no attempt was made to present techniques, rules, or the development of the sports included.

The term sport is derived from the word disport (spelled dysporte, in the fourteenth century). According to *A New English Dictionary on Historical Principles* (32) disport meant sport, pastime, recreation, pleasure and was first used in the literature in 1303. This work stated that Cotgrave had used the French term *se desporter*. Skeat (36) traced the same word to DuCange.[2]

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[2] Charles Du Fresne Sieur Du Cange's, *Glossarium Mediae et Infimae Latinitatis*, in five volumes, was first published in 1678. In it, the following phrase may be found. "De porter praeterea resurparunt, pro Oblectari, recreare, vulgo Se divertir, se rejouir" which loosely means among other things, to divert or delight oneself, to restore or recreate oneself openly, or to exercise for enjoyment.

A search of Cotgrave's *A Dictionaire of the French and English Tongves,* published in 1611, showed no evidence of the existence of the term *se desporter.* However, Cotgrave did use the term *se deporter* which, among other things, meant "to disport, play, recreate himselfe, passe away the time."

The modern term sports has been defined as: (a) "that which diverts, and makes mirth, pastime . . . game or mode of amusement . . . diversion of the field . . ." (41); (b) "any play, pastime, game or contest involving a reasonable degree of individual skill and physical prowess . . ." (12); (c) "that which makes with pastime, amusement . . . play or game . . . such as rowing games, hunting and fishing . . . contest . . . involving physical prowess and individual skill . . ." (13); (d) "sports specifically connotes those activities which require certain patterns of athletic executions which must be performed with some skill and which often must conform to prescribed rules . . ." (4); and (e) "Pleasant pastime; entertainment or amusement; recreation, diversion in participation in games or exercise, especially those of an athletic character (36).

For this investigation the term sports is interpreted in a broad general sense and embraces all those activities which require physical performance (movement), involve some degree of skill and/or conditioning, and embody a pattern of performance and/or a set of recognizable rules. No one particular sport necessarily qualified under all of the requirements listed above.

Methodology

This study involved principally the use of the historical-bibliographical method of research. Contrary to the historiography concept of Fling (17), Nevins (33), and Garraghan (19) where the observer (researcher) neither controls nor evaluates the data, a provisional attempt was made to interpret some of the findings in the light of chronological and social implications.

Critical valid historical research embodies the concept of the unique circumstance (17) or the significant phenomenon (1). In any such historical study of man three basic factors must be considered. They are: (a) past facts, sometimes referred to as past actuality; (b) remains of the past left by society, often referred to as documents and/or artifacts; and (c) a synthetic re-creation of the past, often referred to as historiography. For the most part, historiography is merely the vehicle utilized to recreate as accurately as possible, past actuality. Such a method necessitates extensive use of artifacts and documents. Inasmuch as the historical researcher is at least one removed from past actuality, he must rely almost entirely upon credible documents and genuine artifacts.

One of the most difficult problems in the search for historical truth is, of course, the establishment of fact. A particular event which occurred can never again be repeated or reconstructed exactly in the same way. Even the account of eye witnesses, which is considered a primary source under certain circumstances, is difficult to accept at times because it is essentially a record of the impression made upon the witness (17). The witness recorded

what he thought he saw or heard, not necessarily what actually happened or was said. One suggested method which might help at this juncture is the affirmation of two or more independent witnesses (23). In order to establish evidence in this way, the statements should not differ in important points nor agree in every detail (40). Collusion should certainly be suspected if the latter was the case.

No attempt will be made here to relate the use and function of historical criticism. For those interested in a detailed analysis of the use of external (authenticating) and internal (credibility) criticism refer to Gottschalk (22), Nevins (33), and Garraghan (19).

Some of the richest sources for the early beginnings of sports in England were legal documents in such compilations as *Rotuli Parliamentorum* (35), *Statutes at Large from the Magna Charta* (8), *A Collection in English of the Statutes now in force, continued from the beginning of the Magna Charta* (8), and the *Lavves and Acts of Parliament, Maid Be King Iames the First . . .* (27). Other early sources pertain to the techniques of how the sports were played as well as to their origin and development. Some such sources are Nichols' *Progresses of Queen Elizabeth* (34), James I's *Basilikon Doron* (24), Cleland's *The Institvtion of a Yovng Nobleman* (7), and Burton's *Anatomy of Melancholy* (5).

Another notable early source is Stow's *Survey of London* (39), first published in 1603, which included a translation of the very valuable document of William Fitzstephen called *Descripto Nobilissimae Civitatis Londoniae* which, in turn, was found in the preface of Fitzstephen's *Life of Thomas Becket* written in 1174. Gaston de Foix's *Livre de Chasse,* published in 1387, probably the earliest comprehensive treatise on the sport of the field, is devoted especially to hunting and has been almost literally translated in *The Master of Game* by Edward, Second Duke of York (16). This work is considered the oldest treatise on the subject of the chase in the English language. *The Boke of Saint Albans* (3), attributed to Dame Juliana Berners and published in 1486, is an important source of information on early hunting, falconry, and heraldry. Frederick II's *De Arte Venandi Cum Avibus* (18), written sometime between 1244 and 1250, is a masterly and comprehensive treatise on falconry and hawking as the sport was known during the Middle Ages.

Some dates of origins could be definitely fixed; some could not. In some cases, it was only possible to fix a date *ante quem* and *post quem.* The critical point to be determined was the date before which time it was reasonably certain that the sport did not exist and after which time it was certain to have been in existence. For the most part, only when a date could be established beyond reasonable doubt was it included. The writer may have erred, in some instances, on the side of conservatism; quite probably, some of the sports included have an older history than that indicated but reasonable proof thereof is lacking. The sport of archery is a case in point. It is probable that for many years the bow and arrow played a triple role, of

TABLE 1.—CHRONOLOGICAL DISTRIBUTION OF ESTABLISHED DATES OF ORIGINS

The date given after each sport is that of the earliest documented evidence of its origin in organized form. Dates shown in parentheses are those of documented evidence of previous existence, as unorganized or noncompetitive activity. A date in parentheses with a question mark indicates that reputed evidence previous to this date may not actually refer to this specific sport.

Sport	*Date of Origin*
Wrestling	(2160) 1788 B.C.
Boxing	(2160?) 850 B.C.
Field Events	(900 B.C.?) 776 B.C.
Track Events	(900 B.C.?) 776 B.C.
Hunting	(2357) 400 B.C.
Kite Flying	(1121) 221 B.C.
Coursing	7 A.D.
Cock Fighting	77
Angling	200
Falconry	350
Horse Racing	(648 B.C.) 1174
Tennis	1230
Lawn Bowls	1366
Quoits	(450 B.C.) 1409
Golf	(1380?) 1457
Target Rifle Shooting	1498
Fencing	1517
Hurling	1527
Shuffleboard	1532
Archery (target)	(1530) 1585
Billiards	(1520?) 1590
Fowling	(2475 B.C.) 1596
Polo	(475?) 1596
Curling	1607
Ice Skating	(500) 1659
Cricket	(1600) 1744
Fives	1746
Yacht Racing	(1675) 1775
Pedestrianism	(1610) 1792
Racquets	(1555) 1799
Horseshoes	(1750?) 1801
Coaching	(1590) 1807
Steeplechasing	(1740) 1810
Mountaineering	(1780?) 1811
Gymnastics	(1790) 1816
Pigeon Racing	(1800) 1818
Harness Racing	1825
Sculling	(1715) 1839
Lacrosse	(1400) 1839
Rowing	1839
Bowling (Ten Pins)	(1600) 1840
Croquet	1840
Handball	(1500?) 1840

Sport	*Date of Origin*
Baseball	(1750) 1846
Rugby	1846
Iceboating	(1720) 1850
Weight Lifting	(1720) 1854
Canoe Racing	(1790?) 1859
Soccer	1859
Squash Racquets	1859
Swimming	(1530) 1859
Roller Skating	1863
Trap Shooting	1866
Field Trials	1866
Bicycle Racing	1868
Badminton	1870
Skiing	(1750) 1870
Target Pistol Shooting	1871
Model Sailboat Racing	1872
Lawn Tennis	1873
Football (American)	1874
Dog Racing	(1810?) 1876
Roque	1879
Ice Hockey	(1810) 1880
Rodeo	(1830) 1880
Judo	1882
Tobogganing	(1837?) 1883
Water Polo	1885
Field Hockey	(B.C.?) 1886
Birling	1888
Table Tennis	1889
Darts	(1850?) 1890
Rope Spinning	(1850?) 1890
Squash Tennis	1890
Basketball	1891
Automobile Racing	1895
Volleyball	1895
Jai Alai	1896
Paddle Tennis	1898
Motorcycle Racing	1902
Corkball	1904
Motorboat Racing	1904
Model Airplane Flying	1905
Airplane Flying	1907
Soaring	1909
Speedball	1920
Softball	(1890) 1923
Miniature Golf	(1860) 1927
Soapbox Racing	1927
Six Man Football	1933
Skin Diving	1934
Miniature Auto Racing	1936
Water Skiing	1939
Skish	(1880?) 1939
Flickerball	1948

warfare, livelihood, and recreation, and the problem was to determine a point after which time archery was definitely practiced as a recreational activity, that is, as a sport.

Conclusions

1. The evidence shows that there was a substantial increase in the number of sports introduced during the nineteenth century (see Table 1). A close relationship seems to exist between the increase of leisure time, in part induced by the Industrial Revolution, and this development. Of the 95 sports covered, 49 or 52 percent came into being during the nineteenth century. A combination of the figures for the nineteenth and the twentieth centuries reveals that 65 or 68 percent of the sports reported originated during this period.

2. England and the United States are the sites of origin for 56 or 59% of the sports covered (see Figure I). When considered from a world-wide sports viewpoint, this is interesting. One of the limitations imposed upon the study was to include only those sports practiced principally in English speaking countries, and under such limitations, one would normally expect a larger percentage of the sports' origins to have been attributed to England and/or the United States. If the study could have included the origins of all known sports, the percentage reflecting the origins traced to England and/or the United States would no doubt have been reduced.

3. Of those origins attributed to the United States (a total of 24), 17 or 71 percent occurred since the relatively late date of 1890. Many of these sports are not particularly popular or universally practiced. This finding implies a rather late sports awakening for the United States compared to the older European cultures. This may be because the results of the Industrial Revolution may not have affected the sporting life of the people of this country until late in the nineteenth century. It has been rather well established that the Industrial Revolution did not fully develop here until after the Civil War.

4. In a general sense, it appears that of the 95 sports covered (see Figure II), three emanated from children's play activities (examples: basketball and volleyball), four came out of a search for food or livelihood (examples: hunting and fishing), 26 evolved from what might be termed natural activities such as transportation and communication (examples: skiing and pedestrianism), eight were originally affiliated with religious or ceremonial activities (examples: tennis and lacrosse), two emerged from scientific exploration (examples: mountaineering and soaring), 13 resulted from activities primarily used in warfare (examples: archery and target rifle shooting), six came from work activities (examples: rodeo and birling), and finally, 22 of the original 95 sports were left unclassified because of lack of supporting evidence.

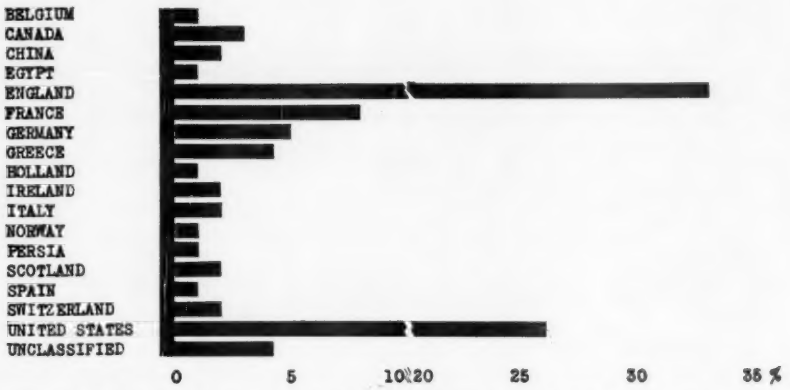

FIGURE I. Percentage distribution of place of origin for 95 sports.

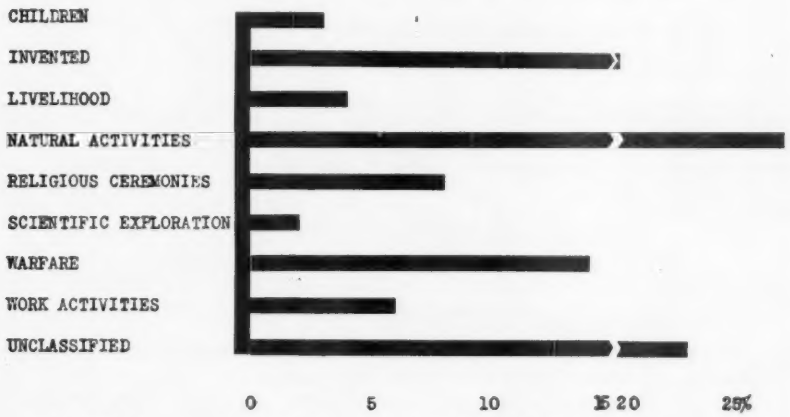

FIGURE II. Percentage distribution of activities from which the 95 sports evolved.

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Influence of Abdominal Strength, Back-Extensor Strength, and Trunk Strength Balance upon Antero-Posterior Alignment of Elementary School Girls

M. MARILYN FLINT and BOBBIE DIEHL
University of California, Santa Barbara
University, California

Abstract

This study was undertaken to investigate the relationship between antero-posterior alignment of the trunk and strength of the muscles which flex and extend the trunk. Two hundred and ten elementary-school girls were given abdominal and back-extensor strength tests; postural photographs were evaluated to determine antero-posterior alignment. The results showed significant relationships between trunk strength and alignment. A low but definite relationship exists between back-extensor strength and alignment.

DURING THE ELEMENTARY school years of growth and development, many postural patterns of adult life are formed. Great concern has been centered upon the posture of elementary school children for this reason. There seems to be some doubt, however, as to which factors influence posture during the formative years. Muscular strength is believed to be associated with postural characteristics, but the extent of influence of specific muscular groups is a subject of controversy.

Particularly for purposes of preventing postural deviations during the formative period, there is a need to determine specific muscle groups whose relative strength or weakness is directly related to postural characteristics. It was the purpose of this study to investigate the relationship between the muscular strength of the trunk and the degree of alignment in antero-posterior standing posture. Only the alignment of the trunk area is considered in the current investigation, and the term antero-posterior alignment refers only to the alignment of this specific area.

The muscular strength of the trunk is viewed here in terms of three factors: the trunk extensors (the back-extensor muscles), the trunk flexors (abdominal musculature), and trunk-strength balance (as indicated by the ratio of abdominal strength to back-extensor strength for each subject).

Review of the Literature

In considering the factors which influence the maintenance of a well-aligned posture, there is general agreement that body balance, good or poor, is dependent upon the quality of muscles and their function (3, 5, 20, 23). Robinow and associates (18), in an analysis of children's posture, state that "inadequate muscle action is involved in

the majority of postural variations and defects of children," but the low correlations obtained suggest that specific regional strength is involved rather than entire body strength.

Ringo (17) used 180 college women as subjects for an investigation of abdominal and trunk-extensor strength and antero-posterior erectness. Using objective measurements on photographs to determine the subjects' antero-posterior erectness and taking measurements of abdominal and back strength, she concluded that a low but definite relationship existed between posture and trunk-strength imbalance among college women. Her findings also showed the ratio of trunk-extensor strength to abdominal strength to be 2:1 on the basis of means and 2.5:1 on the basis of standard deviation.

Some authorities believe that the extensor muscles of the back are responsible for the maintenance of good body alignment (1, 8, 14, 15), whereas others (16, 19) maintain that the strength of the abdominal musculature is also an important factor. Metheny (13) believes that the pelvis is held in its proper position by the strength of the abdominal muscles. This belief was not substantiated, however, in a study by Fox (6), which indicated that apparently neither sway-back nor faulty pelvic tilt was associated with any significant weakness of abdominal musculature in the group studied.

One of several objective methods of evaluating antero-posterior erect posture is the Massey posture test, devised in a 1943 study (11). A validity coefficient of .97 was obtained for the final test items, and substantially high correlations were obtained with other accepted posture tests. Massey concluded that antero-posterior posture may be accurately and objectively measured by the method presented in this study. While Fox (7) states that it has been difficult to duplicate the results of Massey's study using other groups, no studies which dispute the test could be found in the literature. Reference to the test may be found in several textbooks (4, 10, 12). Mathews (12) describes it as "a usable and accurate method of measuring standing antero-posterior posture."

Procedures

Subjects. Two hundred and ten school girls from three Santa Barbara city elementary schools served as subjects for this investigation. Thirty subjects were chosen on the basis of availability from the following grade levels: kindergarten (ages 5-6), 1st (ages 6-7), 2nd (ages 7-8), 3rd (ages 8-9), 4th (ages 9-10), 5th (ages 10-11), and 6th (ages 11-12).

Tests. Tests of abdominal and back-extensor strength were given by the cable-tension method similar to that described by Clarke (4). Posture pictures were rated in a manner similar to that prescribed by Massey (11, 12) to obtain a measure of each subject's alignment.

Equipment. The cable-tension method employed for measurement of abdominal and back-extensor strength was administered on a plinth; a cable, running through a rectangular hole cut in the table top, was attached at one end to a chest harness worn by the subject and was bolted into a two by four under the table. Readings of the amount of pulling force exerted upon the cable by the subject were converted, by means of interpolation of a calibrated chart, into actual pounds of pull.

Posture photographs were taken on black and white film, by 35 mm Kodak camera set on a tripod at a distance of approximately eight feet. Illumination was provided by three floodlights. Measurements were made upon posture photographs through use of a metric ruler and a clear plastic protractor of 360°.

ADMINISTRATION OF THE TESTS

Strength Tests. Subjects were taken to the testing room in groups of six; the apparatus and its purpose was explained to them. Abdominal tests were administered with the subject starting from a hooklying position (back lying, knees bent, feet flat on mat.). To eliminate the use of the hip-flexor muscles the feet were stabilized, and the hands were placed on the stomach. The subject was instructed to leave her hands on her stomach and to curl up and try to touch her nose to her knees without using her arms or elbows. Back extensors were tested in like manner, with the subject pronelying on the table, feet stabilized, and hands placed at the small of the back. The subject was instructed to bring her head up so that the top of it touched her toes.

Three trials were given each subject, in the following manner: (a) back-extensor test, abdominal test, followed immediately by the second back-extensor test, and the second abdominal test, (b) rest period of approximately 10 minutes, with the subject sitting down, and (c) third back-extensor trial, followed by third abdominal trial.

Motivation for the tests was furnished by the tester and assistant, by the cheering of the subject's classmates, and by competition among subjects to exceed both the scores of their classmates and their own previous scores.

Alignment Measurement. Upon each subject two pieces of black tape were placed over bony landmarks, one over the lateral tip of the acromion process of the scapula and one over the lateral surface of the greater trochanter of the femur. Subjects stood in a natural and relaxed antero-posterior pose.

Angles II and III of the Massey posture test were measured to evaluate the subject's antero-posterior trunk alignment (Figure I). Other angles were eliminated from the test because they were not concerned with the alignment of the trunk. Angle II[1] consisted of lines connecting the acromion process to the midpoint of a horizontal line drawn from the abdomen to the spine at the umbilicus level (spinal-abdominal line) and to the greater trochanter. Angle III consisted of lines connecting the mid-point of the spinal-abdominal line to the greater trochanter and to the mid-point of the knee joint. The angles were recorded in terms of deviation in degrees from a straight line. The sum of degrees of deviation of the two angles constituted the antero-posterior alignment rating.

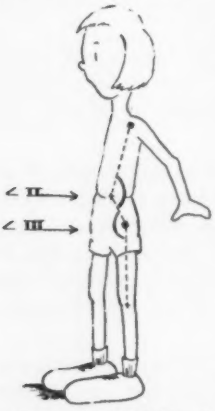

FIGURE I. Marking of angles II and III.

STATISTICAL TREATMENT OF DATA

The greatest abdominal and the greatest back score obtained by each subject during the three trials were retained as measurements of abdominal and back strength. The mean scores, median scores, and standard deviations of each grade level for back-extensor and abdominal strength were determined.

[1] The measurement of Angle II is a variation from the Massey Test. The lateral tip of the acromion process was used as the superior reference point rather than "a mid-point bisecting a horizontal line drawn from the suprasternal notch to the spine (14)."

Means and standard deviations were calculated for alignment ratings.

A "trunk-strength balance index" was obtained for each subject by use of the following formula[2]

$$\text{SI (single index of ratio)} = \frac{c\,A - B}{c\,A + B}$$

where:

A = abdominal strength raw score

B = back strength raw score

c = constant obtained by dividing the median back-strength score of each group by the median abdominal-strength score for that group.[3]

The constant, c, used in the formula is actually the ratio of median back strength to median abdominal strength and is itself a useful measure for comparison.

The resultant index of trunk-strength balance was in decimal form; a zero indicated perfect balance between abdominal and back muscles, a plus value indicated that back musculature was not as strong as average, and a minus value signified that abdominal strength was lower than average. The trunk-strength balance index was used here without any distinction between an abdominal or back-strength weakness and merely as an indication of the amount of deviation from "perfect" balance.

Relationships between the alignment rating and abdominal strength, between the alignment rating and back-extensor strength, and between the alignment rating and the degree of deviation from perfect trunk-strength balance were studied by means of the Pearson product-moment zero-order method of correlation. Separate product-moment coefficients of correlation were also calculated for each grade level to determine the existing relationships between these variables within grade level groups. Standard error of the resulting coefficients of correlation was determined by use of the formula

$$\sigma_r = \frac{1 - p^2}{\sqrt{N - 1}}$$

and significance was determined by the formula

$$t = \frac{r}{\sigma_r}$$

Analysis of Data

An increase in mean and median scores for both abdominal and back-extensor strength from the kindergarten to the fifth grade level is shown in Table 1. An exception to this gradual increase occurs at the third grade level, where both abdominal and back-extensor strength drop noticeably;

[2]The original formula was devised by W. J. Dixon of the University of Oregon and used by Ringo (19).

[3]Median scores were used to obtain the constant rather than standard deviation (used by Ringo), to reduce the influence of extreme scores of the distributions. This constant was determined for each of the seven grade levels, in order to obtain a ratio which was accurate for the strength scores within the various grades.

TABLE 1.—MEANS, MEDIANS, AND STANDARD DEVIATIONS OF STRENGTH AND ALIGNMENT MEASUREMENTS (SEPARATE GRADES)

Measures		KD	1	2	3	4	5	6
Abdominal Strength (lbs.)	M	16.35	18.65	25.00	21.50	36.35	37.30	31.03
	Med.	14.15	18.20	21.65	20.70	36.25	38.21	36.50
	σ	12.80	8.30	19.40	6.90	10.50	11.00	10.00
	Q	9.80	5.28	9.65	7.65	12.80	4.45	6.50
Back Strength (lbs.)	M	47.49	52.00	65.85	63.38	75.15	83.40	72.70
	Med.	49.50	54.15	67.50	62.25	75.80	81.50	70.50
	σ	9.63	12.40	14.65	13.00	16.50	15.00	17.32
	Q	8.18	13.95	9.62	4.50	11.57	10.94	5.90
Trunk-Strength Balance Deviation (lbs.)	M	.318	.222	.245	.072	.122	.133	.090
	Med.	.425	.163	.289	.143	.065	.134	.128
	σ	11.50	7.37	6.38	7.37	5.43	4.35	5.46
Alignment Rating (Degrees of Deviation)	M	33.50	38.50	29.60	35.00	26.50	28.70	34.40
	Med.	35.86	27.31	19.17	35.50	26.00	25.00	21.89
	σ	14.5	17.0	15.6	12.9	13.8	15.3	14.5

strength scores also decrease at the sixth grade level. The increase in deviation from alignment (Table 1) does not exhibit a pattern similar to that of the strength scores at the various grade levels. Nor does a pattern exist among the trunk-strength balance deviations, as different strength ratios were used for each grade in the derivation of the balance index.

The ratio between back-extensor and abdominal strength for each grade level varied according to whether the mean, median, standard deviation, or quartile deviation was used in calculation, as may be verified by comparison of the data of Table 2. The ratio obtained by using the median was considered to be the most accurate in every grade level because of the number of extreme scores in the distributions. The ratio of back-extensor strength to abdominal strength gradually decreases during the elementary school period, reaching a ratio of 2.1:1 (on the basis of median scores) at the 4th and 6th grades. The ratio at these grades is identical to that found by Ringo (17) for college women, on the basis of means.

TABLE 2.—RATIO OF BACK-EXTENSOR STRENGTH TO ABDOMINAL STRENGTH (SEPARATE GRADES)

	KD	1	2	3	4	5	6
On Basis of Means	2.9	2.8	2.6	2.9	2.1	2.2	2.3
On Basis of Median	3.5	2.9	3.1	3.2	2.1	2.2	2.1
On Basis of σ	.8	1.5	.8	1.9	1.6	1.4	1.7
On Basis of Q	.8	2.6	.9	1.7	.9	2.5	1.1

TABLE 3.—COEFFICIENTS OF CORRELATION BETWEEN STRENGTH VARIABLES AND ALIGNMENT (SEPARATE GRADES)

		KD	1	2	3	4	5	6
Abdominal Strength and Alignment Rating	r	.218	—.031	.223	.487[a]	.064	.505[a]	.399[b]
	t	1.18	.176	1.20	2.62	.344	2.72	2.15
Back Strength and Alignment Rating	r	—.096	.095	.084	.191	.106	.125	.072
	t	.516	.512	.452	1.02	.570	.672	.387
Trunk-Strength Balance Deviation and Alignment Rating	r	.328	.122	.096	.230	.026	.428[b]	.405[b]
	t	1.763	.655	.516	1.237	.140	2.301	2.177

[a]Significant at .01 level.
[b]Significant at .05 level.

The results of product-moment coefficients of correlation between alignment ratings (degrees of deviation from alignment) and the three strength variables for each grade level are presented in Table 3. The correlation coefficients between the amount of deviation from trunk-strength balance and the amount of deviation from alignment were significant at the .05 level in the 5th and 6th grades. Coefficients of correlation between abdominal strength and alignment ratings were significant at the .01 level in the 3rd and 5th grades, and they were significant at the .05 level in the 6th grade. Correlation coefficients between back-extensor strength and alignment ratings were not significant at any grade level.

Table 4 presents measures of central tendency and standard deviations concerning the alignment and strength measurements for the total group of 210 subjects. The mean and median of alignment deviation for the total group are higher than those same measures in any individual grade level. The mean trunk-strength balance deviation is higher for the total group than for all of the individual groups except the kindergarten level. Mean abdominal and back-extensor scores of the total group (27.40 lbs. and

TABLE 4.—MEANS, MEDIANS AND STANDARD DEVIATIONS OF STRENGTH AND ALIGNMENT MEASUREMENTS (TOTAL GROUP) (N = 210)

	Means	Median	σ
Alignment Rating (Degrees of Deviation)	40.77	42.29	15.4
Trunk-Strength Balance Deviation (lbs.)	.284	.247	21.6
Abdominal Strength (lbs.)	27.40	26.12	14.21
Back Strength (lbs.)	66.21	67.42	18.5

66.21 lbs. respectively) are slightly lower than the average mean scores of the individual levels (31.03 lbs. and 76.66 lbs.).

Correlation coefficients for both abdominal strength and deviation from trunk-strength balance for the total group (Table 5) were significant at the .01 level. The back-extensor coefficient was significant at the .05 level.

TABLE 5.— COEFFICIENTS OF CORRELATION BETWEEN STRENGTH VARIABLES AND ALIGNMENT (TOTAL GROUP)
(N = 210)

	r	t
Abdominal Strength and Alignment Rating	.271[a]	3.93
Back Strength and Alignment Rating	.174[b]	2.52
Trunk-Strength Balance Deviation and Alignment Rating	.254[a]	3.68

[a]Significant at .01 level.
[b]Significant at .05 level.

Discussion

It has been pointed out that some question exists as to the reliability of the Massey posture test. Furthermore, posture is a dynamic thing. A static photograph can only record the posture of a given individual at the exact instant the exposure was made; it cannot give a full picture of the body alignment of that individual. Yet, according to Swiegard (21), posture patterns are habitual, and Ringo (17) has pointed out that the posture photograph should be typical of postural habit patterns.

An alteration was made in the landmark used to measure Angle II of the Massey test because the lateral tip of the acromion process was more easily found, and the tape could be seen more clearly in the photographs. It must be taken into consideration that with the use of either landmark, Angle II is affected by the degree to which the shoulders are carried forward or backward. Forward shoulders would be more logically associated with the strength of the pectoral girdle than with the strength of the muscle groups studied here, but forward shoulders would still cause an increase in Angle II and a resultantly larger number of degrees of deviation from alignment.

The correlations which used the scores of all 210 subjects were less influenced by single extreme scores and were, therefore, considered to give a more valid measure of the degree of relationship between variables studied than did the separate grade correlations. The results of the large correlations showed relationship between alignment of the trunk and back-extensor strength to be significant at the .05 level, while the relationship between trunk alignment and abdominal strength and the relationship between trunk alignment and trunk-strength balance were significant at the .01 level. These significant relationships may permit an observer to infer with reasonable assurance that trunk-strength balance and abdominal strength are directly associated with antero-posterior alignment of the trunk, or at least that the strength of abdominal muscles should not be overlooked in the correction

of posture. The results appear to disagree with statements by Rathbone (14, 15) and Bancroft (1), which imply that the back muscles are the only ones which are important in the maintenance of erectness. The results concerning balance between strength of the trunk flexors and extensors are in accord with results and statements of several authors (2, 9, 17, 23).

Conclusions

Within the limitations of this study, the following conclusions seem justified:

1. A relationship between trunk-strength balance and antero-posterior alignment of the trunk was significant at the .01 level.
2. A relationship between abdominal strength and antero-posterior alignment of the trunk was significant at the .01 level.
3. A relationship between strength of the back-extensor muscles and antero-posterior alignment of the trunk was significant at the .05 level.

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Effects of Physical Training upon Total Serum Cholesterol Levels[1]

LAWRENCE A. GOLDING
Kent State University
Kent, Ohio

Abstract

The purpose of this study was to determine the effects of a hard endurance exercise program on the total serum cholesterol levels in young adult men. Four male subjects and four controls were tested for cholesterol prior to any exercise. The subjects participated in a 25-week training period of hard and severe all-out endurance type activities and then were again tested for cholesterol levels. Significances of change in the total serum cholesterol levels before and after exercise were determined, and in all subjects total serum cholesterol levels were significantly reduced.

THE PROBLEM of elevated cholesterol levels has become one of national interest, and many researchers have done considerable work in discovering how levels of cholesterol can be lowered. The effect of exercise has been involved in a number of investigations. In many of these studies, however, the exercise has not been in the form of a steady training program, but rather a submaximal level of work to determine immediate effects of exercise on cholesterol levels.

Review of Related Research

The literature on cholesterol experimentation has dealt with a great many variables to discover which factors caused high cholesterol levels and which factors seemed to lower cholesterol levels. Most of the early experimentation was concerned with the effect of diet on serum cholesterol levels. It appears well established that cholesterol in the diet is not as important as the fat content of the diet. In obesity the serum cholesterol levels do not depend on fat intake alone, but also on the manner in which the fat is utilized. Mann (8) relates an experiment which was carried out to reveal the effect of increased caloric intake on serum lipids when the excess calories were burned through exercise, or when the excess calories were deposited as fat. Healthy young men were observed during a control period and a period of high energy exchange. When the control levels of caloric intake were doubled, the weight was kept constant by strenuous exercise. There was a period of rapid weight gain produced by the cessation of the strenuous exercise and a final period of weight reduction produced by a restriction of nonfat calories. It was found in three subjects who completed the regime that doubling the caloric supply had no effect on the serum lipids so long as the excess energy was dissipated by exercise. When the exercise was restricted and the fat disposition occurred, there was an approximate doubling of serum cholesterol levels.

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[1] This study was made in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the College of Physical Education in the Graduate College of the University of Illinois, Urbana, Illinois, 1958, under the direction of Thomas K. Cureton.

One of the few investigations that has been geared mainly toward exercise and cholesterol is by Keys and others (5) who have done a population study of physical activity and its relation to serum cholesterol levels. The study, although using many populations, centered on the people of Cape Town, South Africa. Men were classified according to light, moderate, and heavy work. The results of this study are somewhat ambiguous, since it is stated that physical activity does cause lower cholesterol levels and yet the conclusion states the opposite. It was concluded that the habitual diet had more influence on total cholesterol than did the physical activity of the group. A criticism of the study in the light of physical education research is the interpretation of physical fitness; heavy manual workers may be strong and robust but may lack endurance and circulatory-respiratory efficiency.

Chailley-Bert and associates (2) completed an investigation in France on the effect of exercise and cholesterol and concluded that exercise readily reduced serum cholesterol if the cholesterol levels surpassed 150 mg./100 ml. of serum. Montoye and coworkers (10) studied the effect of exercise on middle-aged men doing mild exercise and found very little differences before and after training. Pohndorf (11) in a study of two subjects training for swimming reported that both subjects lowered their total cholesterol levels significantly.

Purpose

The main purpose of this study was to investigate the extent to which exercise can lower cholesterol levels. The study measured as carefully as possible the cholesterol levels of four subjects and four controls and then recorded the changes of cholesterol levels of the subjects after an intensive graduated exercise program lasting 25 weeks.

Since this was a case study, no generalizations can be made. The case study method does permit one to examine extensively the changes in an individual and report them. Because of the difficulty in obtaining a large number of adults willing to subject themselves to a rigorous daily program of exercise and the time involved with individual testing, the author used four adult men as subjects.

The subjects were all men from the instructional staff of the College of Physical Education at the University of Illinois who were out of condition and overweight. Motivation for maximal work came from the fact that all the subjects were physical education majors who were anxious to get into a training program. This study offered them the opportunity and imposed on them a discipline which they felt was needed.

The diet was not rigidly controlled in that no diet lists were kept or calories counted. However, any sudden or gradual increase of any food component was to be recorded. Nearly all subjects reported a slight increase in the amount of food ingested.

Some researchers (3, 9, 12) have linked high anxiety levels with high cholesterol levels. Psychological stress was not controlled in this study, but all subjects were tested for anxiety levels (1) as a possible explanation for unaccountable cholesterol changes.

Method

The experiment was divided into three periods; pretraining, training, and post-training. During the pretraining period, the subjects and the controls

were measured for total serum cholesterol levels. Each subject had 10 basal observations of total serum cholesterol in 10 days to establish a mean value and to determine the daily fluctuations. The subjects were also given various standard physical fitness tests to determine a pretraining level of physical condition. Various body measurements including fat and specific gravity were also taken.

The training period consisted of 25 weeks of hard exercise stressing strength and endurance. The subjects met together for one hour of exercise five days a week and were encouraged to participate in a physical recreation activity on the weekends.

After the 25 weeks of training the subjects were again tested. The total serum cholesterol values were again determined, 10 observations in 10 days, to establish a mean basal level. During this period the other tests and measures were again taken to determine a post-training level of physical fitness.

Procedures

Blood samples were collected from the medial cubital vein at about the same time each morning. All samples were collected in the basal state. The subjects stated that they had had nothing to eat or drink for the previous 12 hours. None of the subjects was in any state of stress due to exercise, infection, or undernutrition. In none was the collection of the sample preceded by physical exertion or exposure to heat or cold. About 10 ml. of blood was collected from each subject. The samples were centrifuged and then stored at about +4° C. Only a few samples were stored for more than one day. Before the collection of samples the needles and centrifugal tubes were sterilized by heating. The sample were free from hemolysis.

The modified Bloor, Pelkan, and Allen method (7) for the determination of cholesterol was used in this study. In this method the cholesterol is extracted by an alcohol-ether mixture, and the cholesterol is determined photoelectrically.

In order to calculate the amount of cholesterol for a given sample of blood a graph must be established first to determine the relationship between transmittance on the one axis and cholesterol on the other axis. This is done by finding cholesterol values for solutions containing known amounts of cholesterol. Such solutions are then tested for color reactions and determination of total serum content by the method described.

The standard error of measurement for the technique of serum cholesterol determinations, as performed by the author, has been calculated to be ± .5 (T) or ± 2.5 mg. of cholesterol per 100 ml. of blood. This standard error is the same regardless of the cholesterol level.

The tests that were given to the subjects to determine their relative physical condition before and after the training program were some of the tests routinely given in the University of Illinois Physical Fitness Research Laboratory. Many were given because the author felt that the physical performance capacity might be related to cholesterol levels.

Controls

Four controls were used in this study. The purpose in using controls was simply to observe what occurred in normal total serum cholesterol levels over the period of time of the study. No effort was made to match the subjects with the controls, but by chance the controls were of the same age group and of the same occupation as the subjects.

The controls did not change their mode of everyday living during the course of the study. They were asked not to begin any diet or exercise regime or not to stop dieting or exercising. Any change in their cholesterol levels would then be due to biological fluctuations, seasonal changes, stress, or other factors.

The procedure for taking blood from the control group was identical to that used for the experimental group. Although no standard deviation of daily fluctuations was done on the controls, three samples on three different days were taken to determine whether any great change would appear. It did not.

Three persons in the control group had high cholesterol levels while the fourth was in the normal range.[2] These levels corresponded somewhat with those in the experimental group.

Results

Figure I shows that subject I lowered his total serum cholesterol level from 378 mg./100 ml. ± 6 to 225 mg./100 ml. ± 5 which is significant at the 1 per-

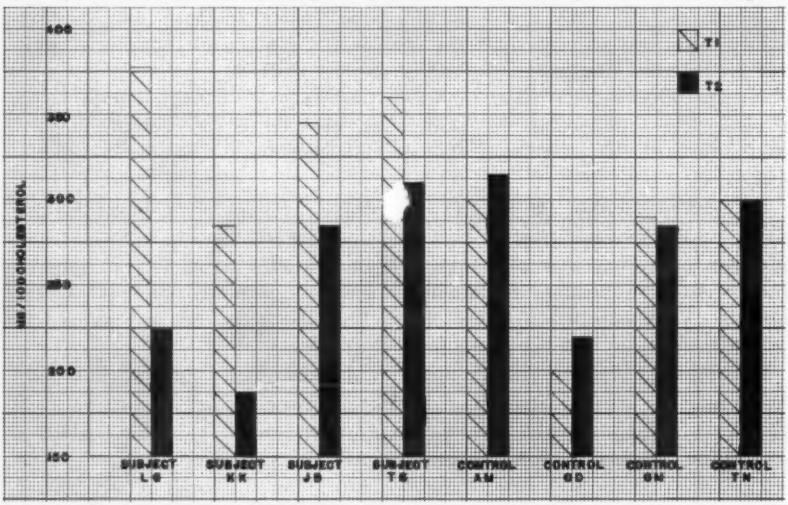

FIGURE I. Changes in cholesterol levels in 25 weeks.

[2] Normal range is generally accepted by most authors to be from about 150 to 250 mg. per 100 ml. of blood.

cent level of confidence ($t = 31.18$). The 153 mg./100 ml. cholesterol reduction represents a 47 standard score improvement. This subject also reduced his total fat from 186 mm. to 100 mm. which represents a 47 standard score improvement. Specific gravity changed from 1.0341 to 1.0751 indicating that the subject lost adipose tissue and gained in density. This subject attended 95.8 percent of the time.

Subject 2 lowered his total serum cholesterol from 285 mg./100 ml. ± 7 to 188 mg./100 ml. ± 10. This represents a 36 standard score improvement and is significant at the 1 percent level of confidence ($t = 12.7$). Subject 2 reduced his total fat by 36 standard scores, from 196 mm. to 130 mm. His specific gravity changed from 1.0355 to 1.0542. Subject 2 attended the exercise program 92.4 percent of the time.

Subject 3 reduced his total serum cholesterol from 345 mg./100 ml. ± 8 to 285 mg./100 ml. ± 8 which represents a 22 standard score improvement and is significant at the 1 percent level of confidence ($t = 8.77$). This subject attended only 53.46 percent of the training period. Subject 3 lost 54 mm. of skinfold fat changing from 180 mm. to 126 mm. His specific gravity changed from 1.0356 to 1.0483.

Subject 4 attended only 44 percent of the training periods. However, he lowered his total serum cholesterol level from 360 mg./100 ml. ± 5 to 310 mg./100 ml. ± 6. This 12 standard score improvement represents a significant difference at the 1 percent level of confidence ($t = 11.65$). Subject 4 reduced his total fat from 192 mm. to 165 mm. which is a 15 standard score improvement. His specific gravity changed from 1.0521 to 1.0595.

Control AM had a total serum cholesterol of 300 mg./100 ml. ± 2.5 on Test 1. After a period of 25 weeks this level was raised to 310 mg./100 ml. ± 2.5. This is within or slightly more than the standard deviation as observed in the experimental subject.

Control CD had average cholesterol on Test 1, 200 mg./100 ml. ± 2.5. This was raised on Test 2 to 220 mg./100 ml. ± 2.5. This, as in Control AM, was a little more than the standard error which has been observed. Both AM and CD raised their cholesterol insignificantly over the period of the study.

Control GM had a cholesterol level on Test 1 of 290 mg./100 ml. ± 2.5. This was insignificantly reduced on Test 1 to 285 mg./100 ml. ± 2.5.

Control TN had a total serum cholesterol level of 300 mg./100 ml. ± 2.5 on Test 1. This did not change over the 25-week period.

Discussion of Data

An obvious fact resulting from the study is that the harder and more often a man exercised, the greater his gain in physical fitness. This appeared to be true in almost all of the measurements.[3] One subject attended 95.8 percent of the time, another 92.4 percent of the time, and these two subjects showed better improvements throughout the test items than did the

[3] Data on fitness test results are available from the author.

other two subjects who only attended 53.4 percent and 44.0 percent of the time. The drop in cholesterol values was inversely related to attendance. Certain measurements followed definite patterns in relationship with cholesterol. The reduction of adipose tissue by exercise seemed to be definitely related in the four subjects concerned. As the adipose tissue was reduced by exercise, so too was the serum cholesterol—the larger the fat reduction, the lower the cholesterol level drop.

To support the reliability of the skinfold fat measurements, it can be noted that the specific gravity values of the subjects increased as the cholesterol levels were reduced. It appeared that cholesterol behaves much as fat does as far as the effect of exercise was concerned.

Cholesterol values in postexercise blood increased as much as 150 mg./100 ml. if exercise is hard enough. Postexercise blood was taken from a large group of middle-aged men after a mile run.[4] The total serum cholesterol values were determined and showed large increases over the resting level. The cholesterol levels returned to normal after the men had recuperated from the run.

It is obvious that the work done in running, or any other single exercise that would be done in a laboratory, is not usually hard enough to exhaust the usually adequate carbohydrate reserves. This is substantiated by the fact that in most all-out treadmill runs the RQ of excess metabolism is too high to show much fat being metabolized.

It appears that the liver may be an important organ in the control of metabolism and deposition of cholesterol. The exercise may increase liver function causing the liver to empty cholesterol into the blood stream. The important questions that need to be answered are (a) how much cholesterol is metabolized? and (b) how is this accomplished during exercise?

As noted, it is doubtful whether a single activity such as an all-out treadmill run is sufficient to metabolize cholesterol. However, when this all-out activity is continued from day to day over a period of months the metabolism of fat becomes obvious with the reduction of total fat and the increase in specific gravity (6).

Closely related to this loss of body weight and loss of fat is the increase in basal metabolic rate. Although no standard scores are available for comparison, it is of interest to note that the four subjects raised their BMR and lowered their cholesterol levels.

The hypothesis that may be presented here is that as excess fat tissue is metabolized through exercise, i.e., exercise hard enough to be beyond the daily caloric intake, so too is cholesterol metabolized. Any physical exercise that is hard enough and persistent enough to in some way change the hormonal balance, thereby raising the BMR, might also lower the serum choles-

[4] Unpublished data from the University of Illinois Physical Fitness Research Laboratory in possession of Thomas K. Cureton. The mile runs were on the indoor U. S. Armory track.

terol levels. Persons suffering from hyperthyroidism have much lower than normal serum cholesterol levels; likewise persons suffering from hypothyroidism have increased serum cholesterol levels. The thyroid gland, besides governing general body metabolism, also seems to exert an influence on serum cholesterol levels.

Studies (4) in animals have shown that rats whose thyroid gland had been removed reacted immediately by increased serum cholesterol levels.

Conclusions

The following conclusions seem justified on the basis of the evidence.

1. Hard endurance exercise given an hour each day over the period of the study reduced total serum cholesterol levels. A significant reduction of cholesterol occurred in all four experimental subjects. Although the small number of subjects prevents any generalizations about the effects on a larger population, the results in this study support results of other similar exercise studies conducted.

2. The four experimental subjects lowered their total serum cholesterol levels (both in raw and standard scores) in the same relationship as the total fat measures. In these subjects, fat reduced as serum cholesterol reduced.

3. Similarly specific gravity tended to parallel the standard score improvement of total serum cholesterol. This shows a tendency toward some relationship between serum cholesterol reduction through exercise and increased specific gravity.

4. The data show that when a man exercises consistently over a long period of time, his serum cholesterol level is lowered to a greater degree than the man who exercises erratically or for a shorter period of time.

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Factor Analysis of Motor Aptitude of Preadolescent Boys

A. H. ISMAIL
C. C. COWELL
Purdue University
Lafayette, Indiana

Abstract

The application of factor analysis with varimax orthogonal rotation was used to extract five factors from the intercorrelations of 25 items which authorities claim measure motor aptitude. The factors underlying the 25 items utilized in the study seemed to permit the following names: speed, growth and maturity classification, kinesthetic memory of the arms, body balance on objects, and body balance on the floor (not on objects).

RECENTLY MUCH ATTENTION has been devoted to motor aptitude as one important aspect of the over-all consideration of individual growth and maturation. Educators are especially interested in verifying the causes of the lack of motor aptitude and its effect on other types of aptitudes. Brace (1) pointed out that aptitude tests in physical education are useful for classification and instructional purposes. The relationship between motor aptitude and mental pattern was pointed out from Heath's (2) work with the rail-walking test.

The term motor aptitude has different interpretations to different people. Through gleaning the literature and consultation with authorities, 25 items claimed to be related to motor aptitude were selected for this investigation. Although the 25 items were empirically agreed upon to contribute to motor aptitude, scientific evidence is still lacking. Application of factor analysis with varimax orthogonal rotation was used in this study to decrease the degree of empiricism. This method of analysis satisfies both the orthogonal simple structure criterion and the concept of factorial invariance. Further, the varimax rotation employs an analytic criterion for rotation which allows factor analysis to become a straightforward methodology stripped of its subjectivity.

In factor analysis, "an analytic criterion for rotation is defined as one that imposes mathematical conditions beyond the fundamental factor theorem, such that a factor matrix is uniquely determined." (3) The first such criterion was Thurstone's treatment of the principal axes problem (4), but this has seldom been accepted as psychologically interesting (5). The rotation problem for psychologically meaningful factors is usually on a basis of individual judgment. Scientifically, this procedure is not very satisfactory. In contrast, the method of rotation adopted is considered an objective and

proper tool for scientific inquiry. The first analytic criterion for determining psychologically interpretable factors was presented in 1953 by Carroll (6).

Factor analysis has been used to explore a wide variety of motor items for the purpose of determining the underlying factors in motor ability. In some studies, the goal was to identify factors which have large scope or dimensions such as strength, power, endurance, speed, coordination, rhythm, and balance (7, 8, 9, 10, 11, 12). Factors which are delimited in scope or dimensions were the aim of some other workers (13, 14, 15, 20).

The investigators did not try in this study to compare these studies and the factors reported in them, because it is difficult, if not impossible, to make such comparison. However, the available information was collated in order to understand differences in motor performance.

Purpose

The purpose of the study was to identify the factors which are present in the selected 25 items that authorities claim measure motor aptitude. Two hypotheses were tested: (a) There are definable factors in the items which authorities claim will measure motor aptitude, (b) Items used for measuring motor aptitude group themselves around identifiable factors such as: growth and maturity, the ability to maintain body balance, the ability to move rapidly, the ability to be aware of time-force relationship, and kinesthesis.

Procedures

The data for the 25 items were obtained from 75 Purdue University faculty sons between 10 and 12 years of age inclusive. The items were as follows:

1. Age in months
2. Height in inches
3. Weight in pounds
4. Physiological age in months (through X-raying the hand and the wrist; X-rays were evaluated at the Philadelphia Center for Research in Child Growth, Pennsylvania).
5. Physiological age using a three-point scale (Crampton Test)
6. McCloy's Classification Index
7. Standing with a single foot lengthwise on a stick and bending forward (eyes open)
8. Standing straight with a single foot lengthwise on a stick (eyes open)
9. Standing on the ball of a single foot on the floor bending forward (eyes closed)
10. Standing straight on a single foot lengthwise on a stick (eyes closed)
11. Rod balance on index finger with replacement
12. Springfield beam-walking test
13. Johnson's stagger jump test
14. Smedley hand dynamometer press

15. Pressure on scales
16. Right arm spread
17. Left arm spread
18. Combined right and left arms spread
19. Cross and vertical lines test
20. Block tapping for speed
21. Soccer dribble test
22. Running and change of direction test
23. Edgren side-step test
24. Softball repeated throws
25. Fifty-yard dash

The Pearson product-moment formula of correlation was utilized in obtaining the correlation coefficients. Among the 25 items 300 correlation coefficients were obtained. The data are presented in Table 1. The principal axis form of solution was used. When complete estimates of the communalities are employed, the number of roots required to account for the total communality is relatively small. Then the varimax program was utilized. This program provides for the orthogonal rotation of the factor matrix in accordance with the Kaiser criterion. All operations were carried out on the Datatron 205 at Purdue University.

Discussion

Five factors were isolated, and the loadings pertaining to the 25 items on these factors were determined. The rotated factor loadings are presented in Table 2. The range in the values of loadings was found to be between + .9559 and — .7160.

Factor I: The soccer dribble item had the highest positive loading followed by the 50-yard dash and the change of direction items in that order. The repeated softball throw item had the highest negative loading followed by the stagger jump, the Edgren side step, the rod balance, the cross and vertical line, and the block tapping in that order. (The positive and negative signs which appeared in the loadings of the items mentioned were due to the difference in the types of the scoring scales.) It would appear that this factor might be given the name of *speed.* In terms of relative contribution, this factor accounted for about 32 percent of the total variance.

Factor II: The item pertaining to the McCloy's Classification Index had the highest positive loading followed by height, weight, physiological age (X-ray of hand and wrist), physiological age (Crampton test), and chronological age, in that order. These are clearly growth and maturity items, and it would appear that this factor might appropriately be called *growth and maturity classification.* In terms of relative contribution, this factor accounted for the largest amount of variance, 33 percent of the total variance.

Factor III: The combined right and left arm spread had the highest positive loading followed by the left arm spread and the right arm spread. These are kinesthetic items, and hence this factor might appropriately be called *kinesthetic memory of the arms.* In terms of relative contribution, this factor accounted for 15 percent of the total variance.

TABLE 1.—MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.		.6051	.4203	.6590	.4822	.7555	.1250	.2971	.0940	.1280	.2579	.1368	.3117	-.0026	-.1971	.1748
2.			.8425	.7590	.6400	.9272	.1284	.1069	-.0142	.1007	.1834	-.1839	-.0074	.1186	-.2485	.1087
3.				.7270	.4586	.8464	-.0009	.0332	-.0280	.0051	.0798	-.3620	-.1443	.1562	-.2435	.0223
4.					.5784	.8100	-.0480	.0124	-.0126	-.0110	.1271	-.1899	.0136	.0466	-.1318	.3405
5.						.5975	-.0004	.0044	.1175	.0609	.0850	-.1275	.0018	.1254	-.2047	.1815
6.							.0599	.1077	.0304	.0857	.1773	-.1900	.0531	.1192	-.2450	.1745
7.								.5247	.1743	.3368	.1129	.3658	.1791	-.0174	-.1539	.0136
8.									.0219	.4242	.1623	.3606	.3241	.1503	-.0290	.0904
9.										.0301	.1667	.2413	.0410	-.1633	-.2021	-.1013
10.											-.0401	.2487	.0925	.1084	-.0120	-.0285
11.												.2534	.3179	.1782	-.0201	.0062
12.													.3351	-.0036	-.0070	.0019
13.														.0584	.0690	.0013
14.															.2185	.0360
15.																.0942
16.																
17.																
18.																
19.																
20.																
21.																
22.																
23.																
24.																
25.																

Factor IV: The items pertaining to standing straight with a single foot lengthwise on a stick (eyes open) had the highest positive loading followed by standing with a single foot lengthwise on a stick in a forward bending position (eyes open), standing straight on a single foot lengthwise on a stick (eyes closed), and the Springfield beam-walking test in that order. Standing on the ball of a single foot on the *floor* in a forward bending position (eyes closed) had a negligible positive loading with this factor. Items number 7, 8, 9, and 10 were designed to measure static balance, while items number 12 and 13 were intended to measure dynamic balance. Accordingly, it is reasonable to conclude that there is some need for additional kinds of differentiation among balance items as to whether they are static or dynamic. The differentiation should be based upon the manner according to which a balance item is executed on an object or on the floor. Hence this factor might appropriately be called *body balance on objects.* In terms of relative contribution, this factor accounted for about 12 percent of the total variance.

Factor V: Standing on the ball of a single foot on the floor in a forward bending position (eyes closed) had the highest positive loading. The balance items executed on a stick or on a beam had either negative or positive

Table 1. (Continued)

17	18	19	20	21	22	23	24	25	
.0829	.1788	.3415	.3583	-.4094	-.3192	.2849	.4092	-.4116	1. Age
.2184	.1962	.0742	.1328	-.2581	-.1729	.1665	.3709	-.3807	2. Height
.1183	.0766	.0274	.0041	-.0056	-.0018	.0595	.1656	-.1008	3. Weight
.1410	.2567	.1265	.0631	-.1571	-.1031	.1007	.2228	-.2506	4. Physiological Age (X-ray)
.1761	.2310	-.0211	.0726	-.2759	-.1647	.2734	.2841	-.2930	5. Physiological Age (Crampton Test)
.1924	.1955	.1601	.1551	-.2397	-.1867	.1696	.3431	-.3456	6. McCloy's Classification Index
-.0619	-.0222	.1966	.1598	-.2433	-.2022	.1234	.1054	-.3100	7. Standing on stick bending forward (eyes open)
.0078	.0735	.1957	.3162	-.2292	-.2959	.1739	.1809	-.2232	8. Standing on stick straight (eyes open)
.0240	-.0666	.4016	.1589	-.1128	-.2161	.2226	.1947	-.2613	9. Standing on ball of foot on floor (eyes closed)
-.0177	-.0424	.1907	.0564	-.0626	-.1094	.0782	-.0212	-.1820	10. Standing on stick straight (eyes closed)
.0270	.0181	.2554	.3629	-.3687	-.3855	.2811	.3922	-.3874	11. Rod balance
-.0025	.0037	.2547	.1184	-.4031	-.3139	.2821	.3004	-.2788	12. Springfield Beam-Walking Test
-.0013	.0038	.5172	.4029	-.5593	-.3803	.2664	.3818	-.4450	13. Johnson's stagger jump test
-.0887	-.0162	-.0851	.0099	.0133	.0373	-.1496	.0180	.0801	14. Smedley dynamometer press
-.0450	.0505	-.0813	-.3077	.0215	.1668	-.0860	-.0704	.1353	15. Pressure on scales
.1781	.8603	-.1800	-.0307	-.0166	-.0430	.0862	-.0030	-.0060	16. Right arm spread
	.6546	.0478	.0286	-.1196	-.1832	.1684	.1219	-.1398	17. Left arm spread
		-.1141	-.0115	-.0759	-.1298	.1541	.0667	-.0910	18. Combined right and left arms spread
			.3690	-.3917	-.2627	.3365	.3715	-.3170	19. Cross and Vertical lines test
				-.3729	-.3631	.2537	.3182	-.3829	20. Block tapping for speed
					.5853	-.4825	-.6140	.6599	21. Soccer dribble test
						-.5181	-.5371	.6362	22. Change of direction test
							.4371	-.3581	23. Edgren side-step test
								-.5600	24. Softball repeated throws
									25. Fifty yard dash

negligible loadings. Hence, this factor might appropriately be called *body balance on the floor* (not on objects). Evidence is presented in support of the name given to factor IV. In terms of relative contribution, this factor accounted for about 8 percent of the total variance.

Results and Conclusions

Five factors were extracted and given names. These five factors seemed to permit clear interpretation by the selected items. Hence, the first hypothesis was held tenable. The factors underlying the 25 items utilized in the study seemed to permit the following names: speed, growth and maturity classification, kinesthetic memory of the arms, body balance on objects, and body balance on the floor (not on objects). Hence, the second hypothesis also was held tenable.

On the basis of the loadings of pertinent items of these factors the following conclusions may be drawn:

1. Measures of motor aptitude group themselves around identifiable factors.

TABLE 2.—ROTATED FACTOR LOADINGS

Variables	Factors					Communality
	I	II	III	IV	V	h^2
1. Age	−.4392	.6298	.0839	.1954	−.0369	.6361
2. Height	−.1458	.9341	.0693	.0759	.0239	.9049
3. Weight	.0954	.8894	−.0584	−.0123	.0158	.8039
4. Physiological age (X-ray)	−.1054	.8480	.1365	−.0591	−.0796	.7587
5. Physiological age (Crampton test)	−.1673	.6406	.1774	−.0482	.0735	.4776
6. McCloy's classification index	−.1741	.9559	.0529	.0578	−.0039	.9502
7. Standing on stick bending forward (eyes open)	−.1636	−.0001	−.0048	.6720	.1398	.4979
8. Standing on stick straight (eyes open)	−.2556	.0304	.0666	.6910	−.1160	.5616
9. Standing on ball of foot on floor (eyes closed)	−.2455	−.0169	−.0626	.0902	.4869	.3097
10. Standing on stick straight (eyes closed)	−.0250	.0436	−.0306	.5947	−.0011	.3571
11. Rod balance	−.5397	.0897	−.0256	.0243	−.0794	.3069
12. Springfield beam-walking test	−.4351	−.2915	.0518	.3810	.0626	.4260
13. Johnson's stagger-jump test	−.6716	−.0872	−.0339	.1735	−.1919	.5267
14. Smedley dynamometer press	−.0000	.1156	−.0594	.0942	−.4263	.2075
15. Pressure on scales	.0318	−.2507	.0672	−.1055	−.4467	.2790
16. Right arm spread	.0296	.0944	.8220	.0671	−.2636	.7595
17. Left arm spread	−.0916	.1334	.5715	−.1185	.2705	.4400
18. Combined right and left arms spread	−.0263	.1396	.9565	−.0189	−.0379	.9369
19. Cross and vertical lines test	−.5296	.0427	−.1662	.1787	.2034	.3832
20. Block tapping for speed	−.4954	.0834	−.0579	.1711	.1047	.2960
21. Soccer dribble test	.8007	−.1049	−.0633	−.0831	.0047	.6631
22. Change of direction test	.6928	−.0597	−.1419	−.1215	−.1885	.5540
23. Edgren side-step test	−.5502	.0812	.1708	.0395	.2485	.4018
24. Softball repeated throws	−.7160	.2302	.0227	−.0323	.0468	.5694
25. Fifty yard dash	.6938	−.2230	−.0682	−.1699	−.1620	.5908
Sum of squares	4.3320	4.4622	2.0966	1.6732	1.0345	13.5985
Percent contribution	31.9%	32.8%	15.4%	12.3%	7.6%	100%

2. There is indication that some factors have not been identified. Six variables have not grouped themselves around any of the factors.

3. Factors IV and V confirm the names given to them. Items measuring body balance may be classified in terms of execution, whether the item is executed on the floor or on objects.

4. Factor II, which involves different measures of growth and maturity, seems to be general in nature. Meanwhile, factor V appears to be a distinct factor.

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Effect of Exercise on Plasma Cholesterol and Phospholipids in College Swimmers[1]

THOMAS F. JOHNSON
HARRY Y. C. WONG[2]
Howard University
Washington, D. C.

Abstract

Young, healthy varsity swimmers were studied over a period of 14 months with regard to the effect of a typical training and competitive collegiate swimming program on plasma cholesterol and phospholipids. Chemical analyses on blood cholesterol and phospholipids were made and compared for competitive and noncompetitive seasons. A dietary analysis was also made during the competitive season. In both the original and subsequent study involving the current (1960–61) varsity swimmers analyses were made of the acute effect of physical exertion on plasma cholesterol and phospholipids.

The exercise, used for conditioning varsity swimming athletes did not significantly lower blood cholesterol and phospholipids. However, this result is not necessarily at variance with the view of some investigators that exercise does exert a hypocholesterilizing effect. Several factors are discussed which are thought to have influenced ultimate results.

INVESTIGATORS have observed that physical activity lowers blood cholesterol. Golding (4), Pohndorf (9) and Montoye (8) noted that physical training resulted in a significant depression of serum cholesterol in men. Schlessinger (10), Mann (6), and Morris (7) found that men engaged in physical work had lower blood cholesterol levels. In animal experimentation, Kobernick (5), Warnock (12), and Wong (13) have demonstrated that strenuous exertion is an effective hypocholesterol agent. Since some investigators have suggested that physical exertion may play an important and dynamic role in the control of plasma cholesterol levels of normal subjects, we wished to investigate the effects of a typical training and competitive collegiate swimming program on blood cholesterol levels of young men. Results obtained during the competitive periods are compared with data from the same athletes during the noncompetitive seasons.

Procedure

Twelve healthy male students, including the coach, in the undergraduate colleges at Howard University participated in the experiment. The training-conditioning program began during the final week of September. Swimmers

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reported to the pool for work twice daily, at 12:00 noon and at 7:30 p.m. Land drills, which preceded water work, consisted of stationary running and calisthenics with special emphasis on stretching and flexibility exercises. During the early phase of the training program, weights, springs, and pulleys were included in the daily workouts. By mid-November these pieces of equipment were eliminated and only a strong preswim calisthenic routine remained for the duration of the competitive season.

The water phase of the workout consisted of swimming one to two miles daily. After the first month of work the mile was covered by swimming a series of 440-yard distances. Later the mile program was changed to a series of 220-yard sprints. In each instance swimmers rested from five to ten minutes between each sprint.

After the dual meet season opened in December, the training-conditioning program was modified to meet more specifically the individual needs in relation to the particular events of each swimmer. Alteration in the program did not significantly reduce the work load. Endurance, speed, pace, stroke perfection, etc. were important goals. Two-a-day sessions were continuous throughout the competitive season except for temporary interruptions for Christmas, New Year's, and semester examinations.

Athletes participated in 11 dual meets; a three-day conference championship climaxed the competitive season at the end of February. Students continued to swim informally during March but did not engage in further competitive sports, intercollegiate or intramural, for the remainder of the school year.

The coach, who exercises habitually, did not follow the exercise or competitive regimen of the swimmers. For him, habitual track work was re-

TABLE 1.—AGE AND WEIGHTS OF VARSITY SWIMMERS

Subjects	Age	Weight (lbs.)		
		Initial	Competitive Average	Noncompetitive Average
CJ	19	170	160	162
MR	19	153	154	155
TJ	41[a]	186	185	185
WL	18	159	161	171
DH	16	145	142	143
MF	20	147	150	145
AE	19	136	135	137
MS	18	153	142	164
JW	22	212	205	217
CW	19	150	148	149
CH	24	170	171	171
BT	18	164	159	158
M	19.3	162.1	159.3	163.1
± SE	0.73	6.3	5.8	6.7

[a] Not included in mean values.

duced during the competitive swimming season to permit inclusion of sprint and distance swimming. Competitive baseball and resumption of the daily track routine replaced swimming for the summer months.

Chemical determinations of plasma cholesterol and lipid phosphorus were made by the methods of Bloor (1) and Stewart (10) respectively. Blood specimens were taken with athletes in postabsorptive state at 7:00 a.m. in the laboratory. Exception to the schedule occurred when specimens were drawn in connection with an actual meet situation and during the months of July and August. In the first instance blood samples (pre and postmeet) were taken at the pool. During July and August trips to homes of the athletes were necessary to obtain blood specimens. In all cases blood was obtained in the postabsorptive state and in the early morning hours.

Subjects were weighed at the time of obtaining blood. A dietary sampling was made to ascertain eating habits and composition for each athlete. During the sampling period (seven days) a written record of everything consumed each day at meals and between meals was made for each swimmer. The dietary records were later analyzed in terms of caloric content and proportion of fat, carbohydrate, and protein in the diet.

Results

Individual ages and the mean age of 11 of 12 subjects at the beginning of the study are presented in Table 1. Initial and final weights for each athlete (competitive and noncompetitive periods) are given, as well as mean weight and standard error for the respective periods.

Table 2 presents individual plasma cholesterol levels with mean values and standard error for the group over a span of 14 months. Unfortunately, it was not possible to obtain specimens for November or June. Blank spaces in the chart indicate that subjects were not available for specimens or that blood was either lost in the centrifuge or not suitable for our particular chemical analyses due to hemolysis. Following hemolysis cholesterol and phospholipid levels may be elevated (especially true for the latter), and thus hemolyzed specimens were discarded. Results for phospholipids appear in Table 3.

Dietary data showing caloric intake and percentage composition of protein, fat, and carbohydrate in the diet of the athletes are shown in Table 4. These data represent a quantitative presentation of a seven-day sampling of diets during the training-competitive season. Cholesterol and phospholipid data for the athletes obtained in connection with a competitive meet appear in Table 5. Data in Table 6 show diurnal evaluation.

Discussion

Questions have been raised regarding the Bloor method for cholesterol determinations, and there has been a tendency to dismiss the method as being relatively inaccurate. However, we used the method and found it quite dependable. In this study comparison of cholesterol results on the same blood specimens analyzed by Harold Orvis, George Washington Uni-

TABLE 2.—COMPARATIVE PLASMA CHOLESTEROL (mg%) VALUES FOR VARSITY SWIMMERS

Subjects	9/29	10/29	12/4	1/9	2/5	3/2	4/8	5/22	7/3	8/5	9/10	10/15
CJ	112	132	142	104	115	125	132	141	114	143	131	131
MR	201	204	184	207	186	198	215	204	—	—	223	190
TJ	181	150	168	157	162	156	173	166	168	195	179	164
WL	184	158	142	179	—	149	158	187	219	224	171	173
DH	221	232	234	229	246	201	278	225	—	—	253	241
MF	227	238	214	250	226	191	232	162	247	276	222	217
AE	151	194	171	—	151	—	205	115	—	—	—	—
MS	158	150	142	162	135	156	181	137	—	—	171	171
JW	115	129	115	136	142	111	121	104	151	180	151	128
CW	141	138	109	136	135	128	136	141	142	163	176	170
CH	163	183	—	211	216	156	197	188	—	—	259	185
BT	—	187	168	193	—	188	—	137	205	238	200	193
M	169	175	163	179	171	160	184	159	178	203	194	179
± SE	11.2	11.4	11.4	13.3	13.1	12.1	14.3	10.1	19.0	19.0	11.6	11.0

TABLE 3.—COMPARATIVE PLASMA PHOSPHOLIPID (mg%) VALUES FOR VARSITY SWIMMERS

Subjects	9/29	10/29	12/4	1/9	2/5	3/2	4/8	5/22	7/3	8/5	9/10	10/15
CJ	159	147	145	154	145	158	163	146	114	126	118	143
MR	229	266	237	255	219	216	232	246	—	—	209	203
TJ	235	228	183	190	186	200	199	209	189	193	201	211
WL	171	223	161	228	191	183	—	226	217	185	177	188
DH	229	256	282	282	263	255	289	272	—	—	252	241
MF	194	241	231	303	263	244	252	276	252	240	221	188
AE	226	218	231	—	203	—	215	236	—	—	—	—
MS	185	194	183	203	192	185	167	201	—	—	177	—
JW	176	194	149	211	192	198	175	163	175	181	191	166
CW	165	176	151	190	169	143	187	187	193	—	189	169
CH	191	247	—	228	215	197	199	207	—	—	223	—
BT	—	—	236	250	191	224	232	244	234	244	197	210
M	196.2	217.3	199.0	226.7	207.7	200.3	210.0	217.8	196.3	194.8	195.9	191.0
± SE	5.8	10.8	12.5	13.5	9.8	10.2	11.5	10.8	19.7	19.7	12.2	8.3

TABLE 4.—AVERAGE CALORIC INTAKE AND PERCENTAGE COMPOSITION OF SAMPLE OF SWIMMERS' DIET DUR!NG TRAINING SEASON[a]

Subjects	Total calories	Protein	Fat	Carbohydrate
CJ	2989	18	47	35
MR	2548	14	48	35
TJ	2200	17	41	42
WL	2298	16	40	44
DH	2098	15	41	42
MF	2236	12	24	64
AE	2669	15	40	46
MS	3254	14	37	50
JW	3494	19	50	32
CW	2282	18	40	42
CH	2222	17	40	42
BT	2415	15	40	45
M	2559	15.8	40.7	43.3
± SE	116.3	0.6	2.2	2.7

[a] Represents average of analyses taken on seven different days during training season.

versity, using the Schoenheimer-Sperry method and by us, using a modification of the Bloor method[3] showed no significant differences. Results obtained by the latter method, if anything, were slightly lower. Duffie (3) found that the two methods for cholesterol determination yield values quite similar. She suggests that the Bloor method probably has an advantage as a research method because it is less time consuming and exacting.

Mean cholesterol and phospholipid data of the athletes do not show exaggerated elevations or depressions. For the most part, individual cholesterol levels, except for subjects DH and MF, were comparatively low throughout the study. It appears at first that the exercise-swimming routine of the competitive season did not have a significant bearing on plasma cholesterol levels. However, upon closer examination, several factors seem to have influenced the outcomes.

Comparatively speaking, base line mean plasma cholesterol value (169 mg %) for this group was low. To depress a cholesterol level which is already approaching the lower limits of the normal range would require a greater physical effort than would be the case for a hypercholesterolemic group. Interruptions in the work program during the competitive season, namely, the Christmas-New Year vacation and semester examinations, no doubt exerted an influence on the downward trend. Prior to December, the athletes worked uninterruptedly for two months. Following an initial elevation, levels began to be depressed. Then came the mid-year recess and semester examination schedule and with this an increase in blood cholesterol

[3] The modification of the Bloor method made by Wong was to allow the serum specimens to stand overnight to precipitate out the protein rather than raise the temperature of the contents in the flask to boiling by placing over a water bath as is outlined in the Bloor method.

TABLE 5.—COMPARISON OF CHOLESTEROL-PHOSPHOLIPID VALUES OBTAINED BEFORE, IMMEDIATELY FOLLOWING, AND THE NEXT MORNING AFTER A DUAL SWIMMING MEET

Subjects	Cholesterol value			Phospholipid value		
	Premeet[a]	Postmeet	Next A.M.	Premeet	Postmeet	Next A.M.
CJ	145	165	142	165	160	145
MR	191	230	184	261	261	237
TJ	184	—	168	200	—	183
WL	148	—	142	181	—	161
DH	234	266	234	261	283	282
MF	238	—	214	241	—	261
AE	264	181	171	275	245	231
MS	150	171	142	256	211	183
JW	128	128	115	176	160	149
CW	109	96	109	149	133	151
CH	264	256	—	245	229	—
BT	184	200	168	251	237	236
M	186.6	188.1	163.0	221.8	213.2	226.7
± SE	12.9	18.9	11.4	9.2	16.7	13.5

[a] Blood specimens taken for pre and postmeet and next morning at 4:00, 8:45, (12/3), and 7:00 a.m. (12/4) respectively.

level. It took 1½ months after examinations of uninterrupted work to again lower the cholesterol level (160 mg %). Except for May (159 mg %) these two periods represent the lowest (163 and 160 mg %) level for the study. When December and March values are compared with July-August-September (178, 203, 194 mg %) the competitive values are considerably lower. No explanation is available for the low value in May. When peak periods are compared, it does appear that the exercise program exerted some influence in spite of not lowering the cholesterol level to or below the base line during the competitive season.

The nonobese nature of the athletes no doubt influenced the possible magnitude of alteration of plasma cholesterol levels. Weight remained constant for the duration of the investigation.

The comparatively low but adequate daily caloric intake may also be considered as an important factor contributing to the low and constant cholesterol level. It may be assumed that the combination of decreased competitive physical activity and an increased caloric intake during the summer vacation accounted for the elevation of mean cholesterol while adequate dieting and physical work combined to maintain a lowered cholesterol level during the competitive season. Dietary habits and caloric intake of the swimmers during the competitive season from the viewpoint of performance and general appearance were entirely adequate. The average caloric value, 2,559 calories, is probably modest when compared with what is commonly considered to be an adequate caloric intake for athletes in training. The percentage composition of protein, fat, and carbohydrate in the swimmers' diet compared favorably with the typical American diet (2).

The low cholesterol level of the group, modest caloric intake, and maintenance of weight control, plus interruptions in the exercise schedule, were important factors influencing final mean cholesterol levels, accounting for the relative constancy of mean cholesterol values throughout the investigation and especially during the school year.

It appears that as long as exercise is adequate to cause utilization of caloric intake and in so doing avoid a positive caloric balance with consequent fat storage as adipose tissue, blood cholesterol may not be significantly elevated in the otherwise normal subject (6, 8, 10). Golding (4) suggests that exercise, when engaged in adequately as to kind, duration, and intensity, among many effects on the total organism, increases metabolism of lipids and cholesterol and thus lowers circulating plasma cholesterol. It is possible that muscle and other body tissue can use fat of fuel as readily as glucose. In fact, fat may be utilized during strenuous exercise in preference to glucose. In prolonged strenuous physical exertion there is hardly sufficient glucose and/or glycogen stores in the body alone to support adequately muscular effort. Thus fat may provide excellent energy source for muscular activity. Through such utilization it may be speculated that plasma levels of cholesterol and lipids, after an initial increase, are lowered as resources are depleted. The fact that blood lipids and cholesterol tend to increase with the onset of muscular effort suggests that the body has a high priority for these resources for fuel to supply increased metabolic needs resulting from acute physical exertion. Such trends may be noted in Tables 2 and 3 for cholesterol and phospholipids by comparing mean values for September-October and similarly for January-February and March, and also by comparing pre and postmeet values in Table 5 (cholesterol). Observed differences here are quite small.

TABLE 6.—DIURNAL EFFECT ON PLASMA CHOLESTEROL-PHOSPHOLIPIDS IN SWIMMERS

Subjects	Cholesterol 4/28		Phospholipids 4/28	
	A.M.	P.M.	A.M.	P.M.
CJ	102	122	163	160
MR	166	163	236	212
TJ	140	135	220	220
WL	151	145	240	208
DH	197	209	284	272
MF	166	158	264	220
AE	148	115	228	220
MS	102	105	176	208
JW	99	105	188	184
CW	114	-----	180	-----
CH	-----	-----	-----	-----
BT	159	158	248	236
M	140	143	220.6	214.0
± SE	8.9	10.4	11.0	11.2

However, in a subsequent study involving nine varsity swimmers differences were greater. This group had a higher mean preswim cholesterol value (228 mg %) than the original group of swimmers (187 mg %). Values for the pre, postmeet, and next morning cholesterol and phospholipids were 228 ± 23, 240 ± 24, and 197 ± 19; 217 ± 12, 243 ± 17, and 211 ± 29, respectively. Even more dramatic were values obtained for two former varsity swimmers who sprinted 220 yards. These subjects were not conditioned for sprint swimming. Mean cholesterol and phospholipids (pre and post) were 254 ± 17, 287 ± 19, 248 ± 12, 305 ± 21, respectively. Values for three controls who entered and remained in the water for three minutes but did not swim showed no change.

The question has been raised regarding possible influence of diurnal effect on values obtained. Data presented in Table 6 show no significant influence. However, values obtained at this time (4/28) and also for the next regular sampling period (5/22) were, interestingly, low. No explanation is available at this time for the low values during this interim period.

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Effects of Stereotyped Nonhypnotic, Hypnotic, and Posthypnotic Suggestions upon Strength, Power, and Endurance

WARREN R. JOHNSON
GEORGE F. KRAMER
University of Maryland
College Park, Maryland

Abstract

On four different days stereotyped nonhypnotic, hypnotic (deep), and posthypnotic (deep trance and light) suggestions were given to 10 young male athletes before they took a battery of three tests: hand dynamometer (strength), jump and reach test (power), and supine press of a 47-pound bar bell to exhaustion (endurance). The entire study was then repeated. The only statistically significant improvements found were in endurance when two of the hypnotic conditions were compared with the no hypnosis condition. None of the hypnotic conditions was found to be consistently superior to the others. However, one subject showed enormous increase in endurance when hypnosis was introduced. Gellhorn's explanation of improved physical performance in emotional states is suggested as a possible explanation of such exceptional performance when it is noted in hypnosis.

THE LITERATURE concerned with physical performances as it is affected by hypnosis leaves unanswered a number of questions which are crucial for the understanding of this aspect of human behavior (5). Undoubtedly, under some conditions, some individuals respond to certain hypnotic suggestions in such a way that their work output is increased—on occasion quite dramatically, as in a case reported in this study. But just what factors are involved in bringing about such improvements when they do occur is not known; nor has it been firmly established that hypnotic suggestions will increase performance, when it does increase, more than nonhypnotic verbal motivating (8).

The present investigation was undertaken to compare the effects of nonhypnotic, hypnotic, and posthypnotic suggestions upon strength, power, and endurance when the suggestions are virtually stereotyped and contain both cognitive and affective appeals, when the subjects are at a relatively high level of physical fitness, and minimum criteria of trance depth are imposed.

Procedures

Eleven male physical education major students and/or athletes presumed to be in at least good physical condition served as subjects. Six were outstanding varsity wrestlers in training; two were track men who, in addition to other activities, ran regularly; one was a varsity lacrosse player; one was a professional football player and wrestler (whose data are reported sepa-

rately); and one was active but not in systematic training for a varsity sport. They were not aware of the nature of the research, although they knew that it had something to do with muscular performance and hypnosis.

All of the subjects had been carefully trained to enter a trance quickly at a signal when asked to do so and to indicate their readiness to receive the suggestions when the desired depth of trance was reached. This signal consisted in having one hand rise spontaneously to the face (hand levitation). The minimum criteria of trance depth were the ability to have complete posthypnotic amnesia as to what took place in the trance; move about as directed in an entirely natural and skillful manner in the trance state; experience visual, auditory, and ophthalmic hallucinations; have awareness of feelings of pain, discomfort, and fatigue greatly modified both hypnotically and posthypnotically; and carry out posthypnotic suggestions compulsively.

The following three physical performance tests were used. (a) Grip strength, measured by a hand dynamometer, was used as the test of strength. The better of two trials was used. The subjects were not told their scores. (b) The jump and reach test was used as a measure of power. In this test, the subject's maximum standing reach is compared with his maximum reach in a vertical jump. The best of three trials was used. The subjects were not told their scores. (c) A weight lifting test, the supine press, was used as the endurance test. The subject lay at full length on his back on a bench narrow enough (11 inches) to permit full depression of the elbows and contact of the bar with the chest. In preparation, he raised his arms three times in cadence with a metronome set for 92 beats per minute (i.e., 46 presses). A 47-pound barbell was then placed in his hands, which were about shoulder width apart. As he performed, the subject stayed as long as possible with the metronome beat. Toward the end of the test when the subject could no longer keep up the pace, he was permitted to continue as best he could without resting, still making full-arm extensions on each press. One investigator counted the presses aloud as the subject performed.

TABLE 1.—MEANS OF TEST PERFORMANCES

Condition	Supine Press (repetitions)			Grip Test (pounds)			Jump and Reach Test (inches)		
	1st M	2nd M	Average M	1st M	2nd M	Average M	1st M	2nd M	Average M
A	42.5	43.5	43.0	112.8	111.1	111.8	19.5	19.1	19.3
B	43.4	45.2	44.3	113.8	112.8	113.3	19.6	19.7	19.6
C	44.2	44.9	44.5	112.2	110.5	111.6	19.3	19.5	19.4
D	43.7	45.3	44.8	111.2	111.7	111.4	19.2	19.4	19.3

These athletically inclined subjects took pride in their performance and gave every evidence of making all-out efforts in all the tests. They practiced all the tests before the study began, the supine press having been practiced at least four times to plateau performance scores and to assure the

avoidance of muscle soreness during the testing period. Information obtained from the subjects indicated that their exercise, eating, and sleeping habits did not undergo marked change during the study. The tests were always taken in the order shown above. Laboratory temperature was maintained between 71 and 73°F.

The test battery of three items was repeated four times, each time preceded by a different condition, as follows.

Condition A. The stereotyped suggestions were given without use of hypnosis as the subjects sat, as they did in all four conditions, with their eyes closed.[1]

Condition B. The suggestions were given while the subjects were in a deep trance, and they performed all tests while in the trance.

Condition C. The suggestions were given in the deep trance for posthypnotic performance, that is, the subjects performed in the fully conscious state after having received the posthypnotic suggestions while in the trance.

Condition D. The suggestions were given for posthypnotic performance, as in Condition C, except that only a very light trance was utilized. That is, at the time of trance induction, the subjects were instructed not to enter a deep trance, only a very light one, the criteria of which were a feeling of being fully awake and aware of the environment (except visually) and a complete absence of posthypnotic amnesia. Before suggesions were given, the subjects were asked to indicate if they were at the desired level of light trance. However, presence of a light trance was demonstrated by suggesting eyelid catalepsy which brought about inability to open the eyes.[2] Performance was out of the trance.

The order of the conditions of the study was rotated from subject to subject, A B C D, B C D A, etc. It was possible for 10 of the 12 subjects to repeat the entire study as a reliability check. The reliability coefficients are shown in Table 2.

An effort was made to stereotype the suggestions, that is, they were read each time in approximately the same manner. However, the individual subject's name was used periodically in set places. The suggestions contained

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[1] It is recognized that trained hypnotic subjects may possibly enter a trance in the presence of the hypnotist without having been asked to do so, and it is therefore conceivable that spontaneous trance states occurred in Condition A. However, these subjects had been trained to enter a trance only when circumstances were entirely appropriate and when asked to do so by this particular hypnotist, and in so far as the investigator could judge, trances did not occur in Condition A.

[2] Although the eyelid catalepsy is commonly regarded as a criterion of light trance and was therefore employed as one of the evidences that the subjects were indeed in a trance, it is not possible to state with certainty whether the subjects actually entered deeper trance states than were desired and responded to the instructions to remain in the light trance state as hypnotic suggestions to be carried out as though in the light trance. Obviously, an individual in a deep trance can be alert to the environment, respond only to eyelid catalepsy. etc., if this is what he understands the hypnotist to desire. However, for whatever this opinion is worth, the hypnotist was of the opinion that the trance was actually light in Condition D.

TABLE 2.—RELIABILITY COEFFICIENTS[a]

	Supine Press	Grip Test	Jump and Reach Test
A1-A2	.840	.819	.725
B1-B2	.847	.773	.935
C1-C2	.782	.875	.728
D1-D2	.861	.778	.812

[a] For reliability coefficients test one was compared with test two of the same condition.

both cognitive and affective appeals and were given in a deliberate, slow, quiet but emphatic manner with no effort being made to whip up the subjects by tone or volume of voice. The same words were emphasized each time (as indicated by the italics). The suggestions were as follows.

The purpose of what I am about to say to you is to help you to become psychologically adjusted for maximum performance on the physical performance tests that you are about to take.

(Name), you are actually *much* stronger than you have ever realized, because as with most people, you have muscular potentialities that you do not ordinarily draw upon even when you try your best. This is why very frightened and very angry people sometimes perform such amazing feats of strength.

In the muscular performance tests that you are about to take, let's see if you can perform at your *full* potential. (Name), begin now to have a feeling that it is *tremendously* important that you make the best possible score on each test. Begin to feel now as though the success of a whole team or saving your own or someone else's life depends on your performance in these tests. Your strength, endurance and power will be *tremendous*. You will be so desperately anxious to succeed that fatigue will not bother you as it usually would. You won't care about it or notice it. The discomfort of fatigue usually stops people before they *have* to stop. But you will be able to keep going on the endurance test much longer than you ordinarily could because you are so strong and fatigue won't bother you. Do you understand, (Name)? Very well. Rest there quietly for a little while and in a few minutes you'll take the tests. You'll be *much* stronger and *much* more powerful than usual.[3]

After the subject received the suggestions once, he was permitted to sit quietly for five minutes and then, depending upon what condition was in effect, he was or was not aroused from the trance and took the tests. The five-minute time lapse was chosen arbitrarily for standardization purposes. (Some time after the present research was completed, one subject volunteered the information that in Condition A and D the five minute time lapse between suggestions and performance gave rise to impatience and irritation, particularly when the study was repeated for reliability.)

Results

Analysis of the data, from which the scores of one exceptional subject were excluded for separate presentation, revealed statistically significant differences favorable to hypnosis between conditions A and C and A and D (5% level) in the supine press test of endurance (see Table 3). There were

[3] While in Conditions B and C most of the subjects began spontaneously to breathe more deeply, to clinch their fists, and give other evidence of excitement.

TABLE 3.—RESULTS FROM COMBINING THE FIRST SET OF TEST SCORES WITH THE SECOND AND COMPARING THESE AVERAGES BETWEEN THE DIFFERENT CONDITIONS

Conditions	Supine Press			Grip Test			Jump and Reach Test		
	$\overline{X}'$	x′	t	$\overline{X}'$	x′	t	$\overline{X}'$	x′	t
A1, 2—B1, 2	1.35	2.91	1.478	1.35	3.22	1.335	.35	.943	1.175
A1, 2—C1, 2	1.55	2.34	2.013[a]	— .6	4.16	— .461	.10	.622	.510
A1, 2—D1, 2	1.50	2.52	1.888[a]	— .4	3.13	— .404	0	.707	.000
B1, 2—C1, 2	.25	3.27	.241	—1.65	2.81	—1.840	—1.5	1.08	— .469
B1, 2—D1, 2	.20	2.98	.212	—1.85	3.36	1.745	— .35	.943	—1.175
C1, 2—D1, 2	—.05	2.06	.076	.10	3.35	1.060	— .10	.706	— .493

[a] Significant at 5% level (1.860 with 9 degrees of freedom).
Conditions: A—Stereotyped suggestions but no hypnosis
B—Stereotyped suggestions and performance in deep trance
C—Stereotyped suggestions in deep trance, post-hypnotic performance
D—Stereotyped suggestions in light trance, post-hypnotic performance
N = 10

no other statistically significant findings. There appeared to be no evidence of improvement in grip strength or power, as measured, when hypnosis was utilized, nor was performance materially altered whether testing was done in the hypnotic or posthypnotic state. However, in the supine press to exhaustion test of endurance, performance did seem to improve consistently when any of the hypnotic conditions were used, but none of the hypnotic conditions when compared with each other was superior statistically.

Professional Athlete's Data

The data obtained from the professional athlete on the endurance test (supine press) were not included with those of the remainder of the group. Whereas the prestudy supine press scores of the others were distributed fairly evenly between 35 and 55, this 235-pound, extremely aggressive, highly mesomorphic (perhaps 5-7-1 by the Sheldon system) athlete pressed approximately 130 in each of his four prestudy practices. He happened to take the test battery in the order, A, B, C, D. His supine press scores were: Test 1—130 (about the same as in prestudy practice); Test 2—180 (when stopped by the investigator); Test 3—230; Test 4—333. Test 2 took place two days after Test 1; the remainder were three days apart. The subject insisted that he did not practice the exercise between testings. He was retested some weeks later with no suggestions or hypnosis involved at all. The investigator again stopped him, after he had completed 350 presses. In all five tests he had a crisis at about each 90 presses, but after a struggle and violent effort he would resume the cadence, sometimes after a burst of rapid presses. The only words spoken during testing were counting of the presses.

Because of the posthypnotic amnesia, the subject did not know his score after Test 2 but commented upon being aroused from the trance that he knew that he'd "sure been through something." After Condition C (posthypnotic suggestions), when he had conscious recall of the testing, he stated that repeatedly he was quite sure that he could do no more but to his surprise

would see his arms rise with the weight. As a habitual weight trainer this did not seem natural to him, and he was very much alarmed and considered withdrawing from the study. When he returned for Condition D he spoke of having a new idea of his performance potentialities and had no doubt of his ability to do still better than before, which he did. It was not possible for him to repeat all of the conditions of the research, but he was asked to return and press the weight without suggestions of any kind. He was certain that he could now do better than ever before because, he repeated, he had a new idea of what he could do. In this postresearch testing he was stopped by the investigator at 350 presses. It may be noted that an appreciable pool of sweat formed under his head during all tests, particularly after Condition A. He reported a complete absence of muscular stiffness on the days following all tests. Some months later this subject was age regressed hypnotically to the occasion when hypnosis was first employed in the test series (condition B). When caused to relive this experience and to verbalize it, he gave evidence of having taken the suggestions extremely literally and to have dealt with the situation on a life or death basis.

A very successful 250-pound professional football player who was a champion field event man and habitual weight lifter was asked to practice the supine press and undergo tests in the same time pattern as the other professional athlete. Neither hypnosis nor suggestions were used, and he was merely urged to do his best. Each performance appeared to be an all out effort. His test scores were 90, 94, 92, and 92.

Discussion

The findings in this study are in accord with such studies as those of Young (10) and Hottinger (2) in regard to grip strength (i.e., no significant increase with hypnosis), but in this same respect they are at odds with those of Roush (9) who found improvements in grip strength measures as well as in an additional arm strength and a grip endurance test. It is noteworthy that Roush had a remarkably large N in consideration of the very deep trance criteria utilized (N= 20). She used both male and female subjects who were, presumably, not in athletic training. Hottinger found that back and leg strength were improved when hypnosis was employed, and Ikai and Steinhaus (4) reported similar findings in regard to arm strength. As in the present study, Hottinger found no statistically significant change in the jump and reach test in the hypnotic state.

There appears to be no information in the literature which is directly comparable to the supine press test, except for a previously reported study by the present investigators (6) and their somewhat similar earlier study of all out effort of short duration (7). In none of these were statistically significant differences found in hypnotic or posthypnotic states except when suggestions were given to worsen performance. However, the remarkable performance of the professional athlete in this test is the kind of thing that greatly complicates the examination of hypnotic phenomena and encourages

the use of such terminology as "transcendence of normal waking capacity" by means of hypnosis (3). Cases of this kind would seem to require an explanation beyond what has so far been proposed.

Gellhorn (1) has pointed out that the increase in muscular strength under conditions of emotional excitement "is due not only to the action of adrenomedullary secretions on the striated muscles but also to the intensification of discharges from the motor cortex resulting from impulses which reach the motor cortex from the hypothalamus." Evidence concerning certain well-known physiological reactions to hypnotic suggestions indicate that hypothalamic and autonomic mechanisms which integrate and mediate innervations associated with emotional behavior are especially responsive to hypnotic suggestions, and it may therefore be reasonable to speculate that the same neural and hormonal effects described by Gellhorn in relation to emotional behavior are involved in the exceptional performance of some people in response to hypnotic and/or posthypnotic suggestions.

Summary

This investigation was undertaken to compare the effects of nonhypnotic, hypnotic, and posthypnotic suggestions upon strength, power, and endurance when the suggestions were stereotyped (i.e., the same suggestions read in approximately the same manner) and minimum criteria of trance depth (e.g., posthypnotic amnesia, somnambulism, analgesia, etc.) were imposed. The tests of strength, power, and endurance were, respectively, hand dynamometer, jump and reach test, and supine press to exhaustion of a 47-pound barbell. The subjects, who were 10 young males presumed to be in excellent physical condition, took all three tests under four different conditions: A—the stereotyped suggestions but no hypnosis; B—suggestions in deep trance, performance in deep trance; C—suggestions in deep trance, performance out of the trance; and D—suggestions in a light trance, performance out of the trance. The conditions were rotated from subject to subject, and the entire study was repeated for reliability.

The only statistically significant improvements found were in endurance when two of the hypnotic conditions were compared with the no hypnosis condition. None of the hypnotic conditions was found to be consistently superior to the other hypnotic conditions.

The endurance test data from one subject, a professional athlete, was too exceptional to be included in the statistical analysis. His uniquely high starting score in the supine press was increased by about 200 when hypnosis was employed. Subsequent retesting demonstrated that this subject was not dependent upon hypnosis for still further improvement in performance. Subsequent age regression analysis revealed the extreme reality and urgency that the subject attached to the suggestions when presented hypnotically. Comparable endurance performances increase did not occur in an even larger professional athlete who, after practice sessions, took the supine press test in approximately the same time pattern as the man involved in the study

but did not receive hypnotic suggestions. Gellhorn's explanation of exceptional physical performance in emotional states is suggested as a possible explanation of the exceptional performance sometimes encountered following hypnotic suggestions.

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(Submitted August 1, 1960)

Development of a Health Knowledge and Understanding Test for 5th Grade Pupils[1]

WALTER C. KLEIN
Southern Illinois University
Alton, Illinois

Abstract

This report is concerned with the development and construction of a valid and reliable test of health knowledge and understanding for 5th grade pupils. Four forms of the preliminary test were administered to pupils beginning the 6th grade of instruction in public schools located in northeast Texas. The trial test was revised after item analysis and use of a statistical procedure to determine valid test items. Analysis of the data secured from administration of the final test to pupils who had just completed the 5th grade of health instruction indicated that the two final test forms were satisfactory measures of health knowledge and understanding.

THE IMPORTANCE of evaluating the outcomes of direct health instruction is recognized by health educators. Standardized health education tests for the elementary grades have been in use since 1928. Pioneer contributions to this area of educational measurement include tests developed by Orleans and Sealy (15), Franzen (3), Brewer and Schrammel (1), and Gates and Strang (10).

Although the early and subsequent standardized tests differ in content and design, they encompass several grades and the greater percentage include the 8th grade. For example, the test devised by Speer and Smith (19) in 1949 is intended for use in grades three through eight. The limitations of tests designed for use at several grade levels has been adequately described by Patty (16), who questions their use as valid and reliable measures of health knowledge and understanding.

The literature devoted to problems in health test construction suggests a definite need for instruments which would more accurately determine the amount of health information children possess at certain periods of their development and progress in school. Therefore, a health knowledge and understanding test for a specific grade level was considered feasible. The 5th grade level of health education was the area explored, and a test was designed for that purpose. In this study, the term "understanding" means the power of individuals to make discriminating choices concerning health problems or situations.

Related Research

The literature since 1930 includes health education tests designed by elementary classroom teachers. Since the classroom teacher would be the most logical person to evaluate

[1] This study was made in partial fulfillment of requirements for the degree of Doctor of Health and Safety, Indiana University, 1958, under the direction of J. Keogh Rash.

the outcomes of direct health instruction, it was significant and somewhat disappointing to learn that no teacher-made tests have been published since 1948.

Ten health education tests, devised by elementary classroom teachers, were found in the literature and reviewed for this study (5, 6, 7, 8, 9, 11, 12, 13, 14, 18). None of the tests included information indicating use of procedures usually associated with standardizing tests. A critical analysis of the measuring instruments enabled the writer to determine health content emphasis and the type of test items utilized by classroom teachers. Although teacher-made tests included all forms of objective type items, the best-answer test item was used predominantly.

Standardized health education tests suitable for elementary grades were also reviewed. The earlier standardized tests were made up of sections consisting of true-false statements, matching questions, completion items, and best-answer questions. Since 1937, authors of standardized health education tests have used the multiple-choice, best-answer item exclusively.

TABLE 1.——CONTENT WORD COUNT IN FIVE SELECTED FIFTH GRADE HEALTH TEXTBOOKS

Content area	Words	Percentage	Items
Anatomy and physiology	60,262	39.00	23
Emotional and social adjustment	25,495	16.50	10
Personal hygiene	23,348	15.11	9
Food and nutrition	22,405	14.50	9
Disease, cause and prevention	15,313	9.91	6
Environmental hygiene	7,695	4.98	3
Total	154,518	100.00	60

Procedure

Five recently published textbooks[2] for the 5th grade were selected to provide the content of the preliminary test. Use of texts on the list of books approved by the Texas Education Agency helped to ensure curricular validity.

After careful analysis and page-by-page word count, six major areas of health knowledge were identified in the selected health books. The area of anatomy and physiology received the greatest amount of textbook description. It was followed in the order of emphasis by emotional and social adjustment, personal hygiene, food and nutrition, disease, and environmental hygiene. Although first aid and safety were discussed in all five health books, this content was not included in the tabulation. It was decided that such related areas would be omitted from a test of general health knowledge.

A table of specifications was developed to establish the percentage and the number of the items required to meet the textbook emphasis for each content area. Table 1 indicates the six major areas, the percentage emphasis,

[2] Baruch, Dorothy: Montgomery, Elizabeth; and Bauer, W. W., *You*, New York: Scott Foresman and Company, 1954. Brownell, C. L., and Evans, Ruth, *Broad Streets*, Chicago: American Book Company, 1953. Burkard, W. E.; Chambers, R. L.; and Maroney, F. W., *Better Health for You*, Chicago: Lyons and Carnahan, 1953. Jones, Edwina; Morgan, Edna; and Landis, P. E., *Your Health and You*, River Forest, Ill.: Laidlaw Brothers, 1954. O'Keefe, Pattric Ruth; Maxwell, C. H.; and Zimmer, Louise, *Getting Acquainted*, Chicago: John C. Winston Company, 1954.

and the number of items needed for each content area in the preliminary and final test.

Test items were devised from concepts found as definite statements or implied by the textbook authors. Because the validity of tests might be affected by reading difficulty, the words in the items were written in language familiar to 5th grade children. *The Teacher's Word Book of 30,000 Words*, by E. L. Thorndike and Irving Lorge, was the criterion for selecting suitable vocabulary. Health words included in the items were those which should have been learned and understood by pupils who have completed the 5th grade level of health instruction.

Four test forms, intended to be identical in content, constituted the preliminary test. Each form consisted of 60 best-answer items with four option choices.

The total tentative test was submitted to a jury of five health education specialists and teachers at a workshop held in Bloomington, Indiana, in August 1956. Each jury member was asked to examine the test items against the following criteria: relevance of the information tested, clarity of the stem or lead statement, lack of ambiguity in the tentative option choices, scientific accuracy of the information, and difficulty of the items for 5th grade pupils.

Following the decision of the judging group, some items were eliminated for reason of ambiguity. Appropriate items, acceptable to the jury, were devised as replacements for the discarded items. Items with inaccurately worded options were rephrased, and the items considered too difficult or easy were revised in accordance with the critics' suggestions. The acceptance of an item by each member of the jury was the required basis for the selection of satisfactory test items.

The 240 test items were assigned to the four forms according to the table of specifications. The correct option choices for the items were arranged by chance selection utilizing numbered discs with the exception of items composed of numerals or letters of the alphabet. The placement of options in the latter was in logical order.

The preliminary test Forms A, B, C, and D, were mimeographed. Each form was preceded by written directions for the examinee and a sample test question. In the fall of 1956, the writer personally administered the preliminary test forms to 1,651 pupils, 880 boys and 771 girls, beginning the 6th grade of instruction in the white elementary schools of nine selected public school systems situated in northeast Texas.

The completed tests were scored by hand and a spot-check was made by another person who picked every tenth paper and examined it for possible errors in scoring and addition. It was necessary to discard 54 test forms for reason of double answers or failure to answer every item.

Analysis and Results

Preliminary statistical treatment of the data secured from the completed test forms was followed by extensive analysis of the test items. The statistical

method used to determine valid items for the final test was the Votaw curve (20). Bridges (2) found this procedure effective for determining discriminating items. The Votaw curve is a delineatory device which is based upon the assumption that in order for an item to be a true measure, there should be a significant difference between the percentage of good students and the percentage of poor students who answer the item correctly. The upper and lower 27 percent of the raw scores in the distribution are included in this analysis, and the proportions needed for plotting the curve are derived from formula. The approach to item analysis described by Rash (17) was also used to determine the worth of items found valid by the Votaw curve technique.

Table 2 presents the number of 6th grade pupils who took each preliminary test form; the range, mode, mean, median score; and the standard deviation of the grouped frequency distribution of raw scores for each form. The reliability coefficient was determined by Froelich's (4) adaptation of the Kuder-Richardson formula.

As a result of the application of the Votaw curve to the test items, 18 items, or 7.50 percent, of the total number in the preliminary test were discarded because they did not discriminate effectively. After item analysis it was found that 24 items, or 10 percent, were beyond the 10-90 percent range of item difficulty and these were also discarded. The items with nonfunctioning distractors were identified. Sixty-two items, or 25.83 percent, had options which were not selected by a minimum of 3 percent of the examinees.

Preliminary test Forms A, B, C, and D consisted of 240 trial items. Of this group, 136 items, or 56.67 percent, were acceptable according to the criteria established for selecting final test items. Although the number secured was in excess of the amount required for two final test forms, 20 items satisfactory from the standpoint of difficulty and discriminating power were not included in the final test. There was a deficit of items in the areas of anatomy and physiology, emotional and social adjustment, and personal hygiene. After careful study of the valid items with one nonfunctioning distractor, four items considered most pertinent to the needs of 5th grade pupils were selected. The frequency of mention by the health textbook authors of concepts posing the central problem provided the basis for determining the selected items. These were revised and used to satisfy the table of specifications for each content area.

The selected 60 items for each final test form were arranged in percentage order of their difficulty from least difficult to most difficult. An effort was made to secure an average level of difficulty of 50 percent for each form. Item difficulty for final test Form A ranged from 88.58 to 21.60 percent; the mean difficulty was 57.25 percent. The difficulty of the items in final test Form B ranged from 85.11 to 22.58 percent; the mean difficulty for this test form was 57.32 percent.

In April and May, 1957, printed copies of final test Form A or B were administered by the teachers to 1,350 pupils, 681 boys and 669 girls, who had

TABLE 2.—COMPARATIVE DATA FOR THE PRELIMINARY TEST FORMS

Test Forms	Number	Range	Mode	Mean	Median	Standard deviation	Reliability
Form A	403	45	43	38.60	39.79	7.95	.8222
Form B	398	47	43	37.60	38.66	8.28	.8087
Form C	396	43	46	42.61	43.94	7.26	.7787
Form D	400	36	37	35.63	36.38	6.96	.7013

TABLE 3.—COMPARATIVE DATA FOR THE FINAL TEST

Test Forms	Number	Range	Mode	Mean	Median	Standard deviation	Reliability		
							Kuder-Richardson	Pearson r (odd-even)	Spearman-Brown
Form A	741	48	37	35.44	36.02	8.47	.8113	.7172	.8353
Form B	714	48	40	35.91	36.77	8.78	.8267	.7737	.8724

just completed the 5th grade of health instruction in the white elementary schools of seven selected public school systems located in northeast Texas. A total of 105 pupils, 56 boys and 49 girls, in this group took both test forms. The data secured from the raw scores made by this group were used to determine interform reliability. The tests were scored manually and all were examined a second time for accuracy in scoring and addition.

The results secured from statistical analysis of the final test data are summarized in Table 3 to facilitate comparison. Interform reliability yielded a coefficient of .8153.

Since each final test form included two items with a revised option, the responses to these items were analyzed to ascertain the effect of option revision. It was found that the options in the revised items functioned, and the discriminating power of the items was not lost as a result of option revision.

Difference of Response Between Sexes

To establish the need of developing separate norms for boys and girls, it was determined if there was a significant difference between the performance of boys and girls on the final test. The standard error of the difference between the two means for each test form was determined, and critical ratios were calculated. A summary of the results is presented in Table 4.

TABLE 4.—SUMMARY OF THE DIFFERENCE BETWEEN BOYS AND GIRLS

Sex	N	M	σ	σ_M	σd_m	CR
			Form A			
Boys	365	34.97	8.78	.4596	.62	1.65
Girls	376	35.99	8.14	.4198		
			Form B			
Boys	372	35.40	9.34	.4843	.65	1.63
Girls	342	36.46	8.09	.4375		

The critical ratio secured for each final test form was not significant at the 5 percent level of confidence. The mean scores for boys and girls on each test form were so similar that there was little to be gained in establishing separate norms. Norms in the form of percentile rank and T scores were computed in order to provide meaningful interpretations of the raw scores made by the pupils who took the final test.

Conclusions

1. The test is a valid and reliable test of health knowledge and understanding for 5th grade pupils.
2. The format and method of the test are in harmony with other subject matter tests commonly used at the elementary level.
3. The final test forms could be used interchangeably as suitable instruments for measuring the health knowledge and understanding of 5th grade pupils.

4. There was no significant difference between the responses of boys and girls on the final test forms.

Appendix

Each of the final test forms consists of 60 best-answer items with four option choices. Included here are items representative of the six major content areas.

FORM A

1. The tonsils help to
    1. warm the air
    2. remove germs from the air
    3. remove oxygen from the air
    4. digest food
2. A true sign of growing up is to be able to
    1. get good grades in school
    2. get attention from others
    3. think of the other fellow
    4. write your own letters
3. Milk is good for children because it
    1. is an almost complete food
    2. makes the teeth white
    3. contains iron
    4. is pasteurized
4. The best way to brush the teeth is
    1. upward then downward
    2. in a circular motion
    3. in the direction they grow
    4. in any direction
5. Germs that cause disease are found
    1. everywhere
    2. in the soil
    3. in the water
    4. in the air
6. Ventilation is a word that means the amount of
    1. fresh air in a room
    2. moisture in a room
    3. light in a room
    4. heat in a room

FORM B

1. Sound that is picked up by the ear moves the
    1. ear drum
    2. Eustachian tube
    3. ear bones
    4. nerves of the ear
2. The best way to find out how grown-up you are is to compare
    1. yourself with your classmates
    2. things you can do now with what you have done
    3. yourself with your teacher
    4. yourself with older children
3. A breakfast of fruit, toast and milk does *NOT* have enough
    1. vitamins
    2. protein
    3. starch
    4. liquid
4. The nose is covered during a sneeze because it
    1. protects hearing
    2. quiets the noise
    3. protects other people
    4. it is good manners to do so

5. The best way to destroy disease germs is to expose them to
   1. sunshine
   2. water
   3. darkness
   4. cold temperatures
6. Pasteurization is a process that
   1. kills bacteria
   2. makes milk whiter
   3. keeps milk from spoiling
   4. removes fat from milk

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Blood Plasma Cholesterol Changes during a Physical Training Program[1]

R. H. ROCHELLE
University of California, Santa Barbara
Goleta, California

Abstract

Blood plasma cholesterol levels were followed in six experimental and six control subjects during a five-week training program (two-mile run for time, five days per week) and an eight-week detraining period. Plasma cholesterol levels were determined by the Duboff-Stevenson ultramicro method.

Plasma cholesterol levels were significantly reduced during the course of intensive training. A temporary rise in plasma cholesterol occurred during exercise, probably indicative of fat mobilization and ultimate utilization during physical exercise. Plasma cholesterol levels returned to pretraining levels within four weeks after training was stopped. The diurnal and weekly blood cholesterol variations were rather small, 2 percent and 2.7 percent, respectively.

The pathways by which exercise assists in the lowering of plasma cholesterol levels are discussed.

ONE OF THE MOST widely talked about medical subjects is that of cholesterol and its implication in atherosclerosis. A correlation between the two seems definite, but the extent of this relationship is the controversial issue (16, 25, 30, 39, 55). The most significant factor indicating a relationship between cholesterol and atherosclerosis is that this sterol is always present in atherosclerotic plaques. Although the great majority of evidence supports the theory that high blood cholesterol levels lead to atherosclerosis, a few studies indicate the contrary (40, 51).

Cholesterol is a waxy substance resembling fat in being insoluble in water and easily dissolved in ether and other fat solvents (26). Although cholesterol is one of the oldest organic compounds, from the standpoint of isolation and recognition, and one of the most widely studied, its functions are still not fully understood. It is found in all living organisms, being present in every tissue. In most animals, the adrenals, particularly the cortex, are the richest source of cholesterol, which is found largely in the combined form as fatty acid esters. The brain and nerve tissue are large repositories of cholesterol (30). The circulating cholesterol is present in two chemically distinct compounds, free or unesterified cholesterol and esterified cholesterol, in which it is usually combined with long-chain unsaturated fatty acids. Kritchevsky (21) lists several roles attributed to cholesterol as these: (1) as a transport vehicle for fatty acids, (2) as an integral structural unit of various tis-

[1]This study was supported by Wood-Glenn Hall Research Grant and University of California Faculty Research Grant No. 138.

sues, (3) as a skin lubricant, and (4) as a precursor of other steroids such as bile acids and sex hormones.

Atherosclerosis is the formation of a plaque or bulge, a mixture of cholesterol and ordinary fats of the blood, between the inner and outer walls of the arteries. It involves mainly the inner layer of the arterial wall, the intima. The plaques can grow until they seriously diminish the lumen through which the blood must flow, but probably more important is the effect on the adjacent cells. The cells of the artery wall are crowded and become ill nourished. Eventually some of the cells actually die, producing areas of ulceration which heal like scar tissue further damaging the normal cells of the wall. Likewise, conditions are set up for a local blood clot to form and thus totally occlude the vessel by thrombosis (26).

Numerous means have been employed to decrease blood cholesterol. Among these, to mention a few, are weight reduction (47), vegetable oils (1, 24), chemicals (4, 10), drugs (22), and exercise. Of these, exercise has been studied the least. It is the purpose of this investigation to study the changes in plasma cholesterol during and following a period of physical training.

Review of the Literature

Chailley, Labignette, and Fabre-Chevalier (8) compared the blood cholesterol levels of sedentary middle-aged subjects with active subjects and found the latter group to have lower blood cholesterol levels. Anderson and associates (2) were able to show that overnutrition with gains in body weight increases cholesterol, while Walker and others (47, 48) found decreases in cholesterol with caloric restriction and loss of weight. Gordon and associates (18) observed decreases in blood cholesterol levels during periods of weight gain when the increase in calories was derived from sunflower seed oil. Mann and associates (31) placed men on high caloric diets and observed increases in blood cholesterol, but when this surplus energy was expended by exercising, no changes occurred. Keys and associates (25), in studying the physical activities of men from different populations, found lower cholesterol levels for those engaged in heavy labor, but attributed this to differences in diet, and in particular, to the fat content of the diet.

Montoye and co-workers (34) report decreases in cholesterol with exercise but only when associated with body weight losses. Taylor, Anderson, and Keys (45) are of the opinion that, in caloric balance, exercise causes no alterations in cholesterol levels. In contrast to this, Rakestraw (43) and Groen and associates (19) found physical exertion to reduce serum cholesterol level irrespective of the subject's diet. Whyte (50) found cholesterol concentrations to be related to age but not to weight or obesity.

In animals it has been shown that exercise lowers serum cholesterol levels of cockerels (49, 53), but causes no alterations of cholesterol in rats and mice (14, 41). Myasnikov (37) was able to show that blood cholesterol levels of rabbits fed cholesterol and exercised daily on a treadmill were lower than those fed cholesterol only. These findings corroborate those reported by Koberinck (29).

Methodology

Subjects. The subjects for this study included twelve normal adults, six of whom acted as controls. Their ages ranged from 20 to 36 years.

Experimental Design. Blood plasma cholesterol determinations were made four times daily on two experimental subjects and three times daily on two control subjects during phase I, a pretraining, and phase II, a five week physical conditioning period. During phase III, eight weeks of detraining, determinations were made twice daily, every second week. Determinations on the remaining eight subjects were made weekly for each phase with the exception of phase I, a two-week pretraining period, when daily determinations were run.

Cholesterol Determinations. Plasma cholesterol determinations were carried out by the Duboff-Stevenson ultramicro method (13).[2] This method utilizes the Liebermann-Burchard reaction, the most widely used of all processes of cholesterol identification. Blood samples, taken from any finger, were collected in four .05 ml heparinized capillary tubes. Blood samples were taken four times daily, 7:00 a.m.; 12:00 noon, before exercise; 12:30 p.m., immediately after exercise; and at 10:00 p.m. Duplicate determinations were computed at various intervals throughout the entire experiment. The 7:00 a.m., 12:00, and 12:30 p.m. determinations were premeal values. The 10:00 p.m. determination was on the average four to five hours after the dinner meal.

Training Program. The program selected for physical conditioning consisted of a daily two-mile run for time. Each day the individual attempted to improve his running time. The times for the two-mile run ranged from 12 to 15 minutes.

Diet. No specific diet was followed, but each subject maintained a daily food consumption chart. Each of the subjects showed consistent eating habits throughout the experiment with saturated fats comprising approximately 35-45 percent of the diet. Body weight and fatfold measurements were taken at the beginning and end of the physical conditioning period.

Results

A statistical comparison was made between: (a) the mean cholesterol level of the pretraining and post-training periods for the experimental group; (b) the mean cholesterol level of the pretraining and post-training periods for the control group; (c) the mean cholesterol level of the post-training and fourth week of detraining for the experimental group; (d) mean cholesterol levels before and immediately after exercise. Diurnal and weekly variations were also determined.

The average cholesterol level of the experimental group for the pretraining period was 203 mg. percent (mg. per 100 ml.). The average post-training level was 179.5 mg. percent (see Figure I). The standard deviation of the

[2] All determinations were carried out by a technologist, W. W. Stevensen, consulting chemist, Santa Barbara.

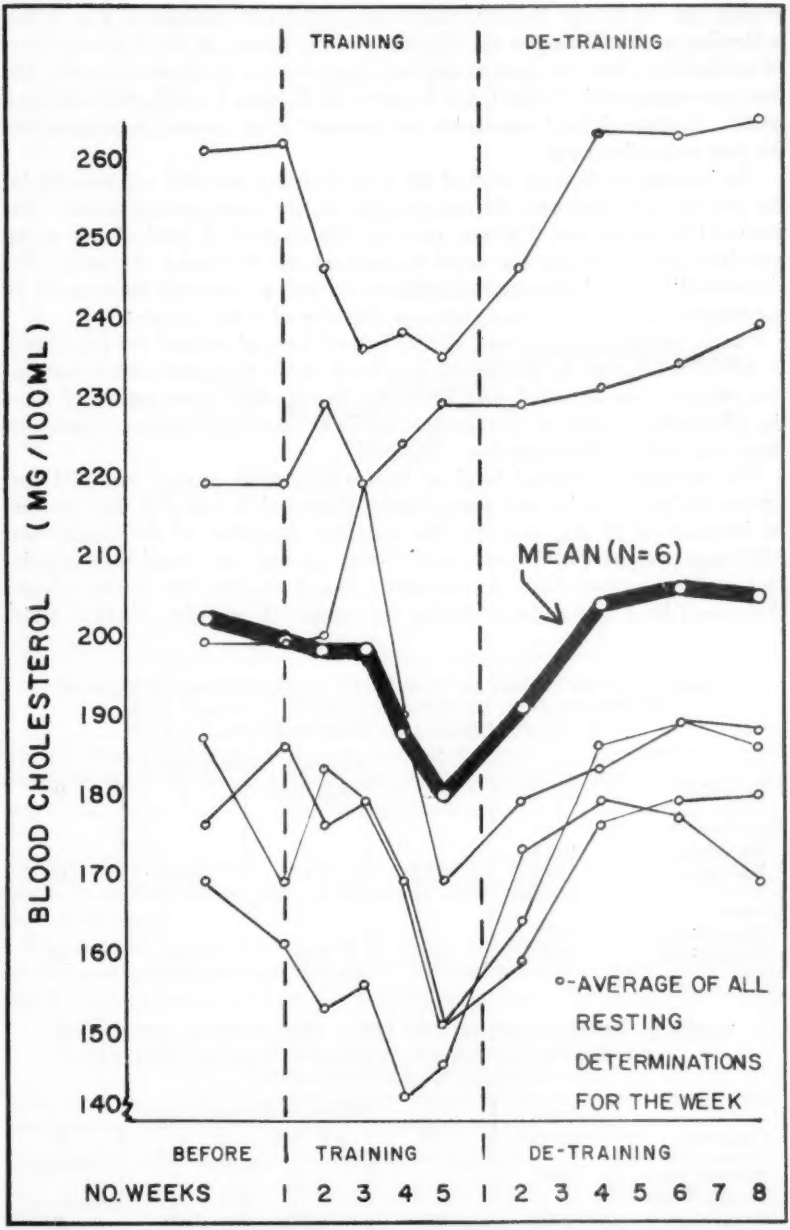

FIGURE I. Blood plasma cholesterol levels of the experimental group before, during, and after physical training.

change was 13.15 mg. percent. Statistical comparison revealed a t of 3.963, indicating a significance in the difference of the means, at the 2 percent level of probability, between pretraining and post-training cholesterol levels. The data are contained in Table 1 and Figure I. In Figures I and II, the individual weekly cholesterol level represents the average of all resting determinations for that respective week.

The average cholesterol level of the control group was 187 mg. percent for the pretraining phase and 188 mg. percent for the post-training period. The standard deviation was 9.38 mg. percent. The cholesterol level of this group remained approximately the same throughout the 16 weeks of testing. The cholesterol levels of two control subjects showed an average increase of 10 mg. percent and of the four an average decrease of 5 mg. percent.

During the detraining phase, the cholesterol level of each of the experimental subjects returned to the pretraining level within four weeks after training was stopped (see Figure I and Table 2). During this same period of time, the cholesterol levels of the control subjects remained approximately the same as previous determinations (Figure II).

The average cholesterol level of the experimental groups was 192 mg. percent before exercise and immediately afterward it was 209 mg. percent, an increase of 17 mg. percent. The standard deviation of the change was 5.376 mg. percent. The difference of 17 mg. percent was found to be significant at the 1 percent level of probability (see Table 3). The resting plasma cholesterol level was reduced during the course of intensive physical train-

TABLE 1.—COMPARISON OF THE MEAN CHOLESTEROL LEVELS OF EXPERIMENTAL GROUP AND CONTROL GROUP FOR PRETRAINING AND POST-TRAINING

Condition	Mean (mg %)	Difference Between Means			
		Diff.	S.E. Diff.	t	P
Experimentals					
Pretraining	202.8				
Post-training	179.5	23.3	6.309	3.966	.02
Controls					
Pretraining	187				
Post-training	188	1	4.195	0.245	.85

TABLE 2.—COMPARISON OF THE MEAN CHOLESTEROL LEVELS OF EXPERIMENTAL GROUP FOR POST-TRAINING AND FOURTH WEEK DETRAINING

Condition	Mean (mg %)	Difference Between Means			
		Diff.	S.E. Diff.	t	P
Postexercise	179.5				
Fourth Week Detraining	204.8	25.3	4.475	5.650	.01

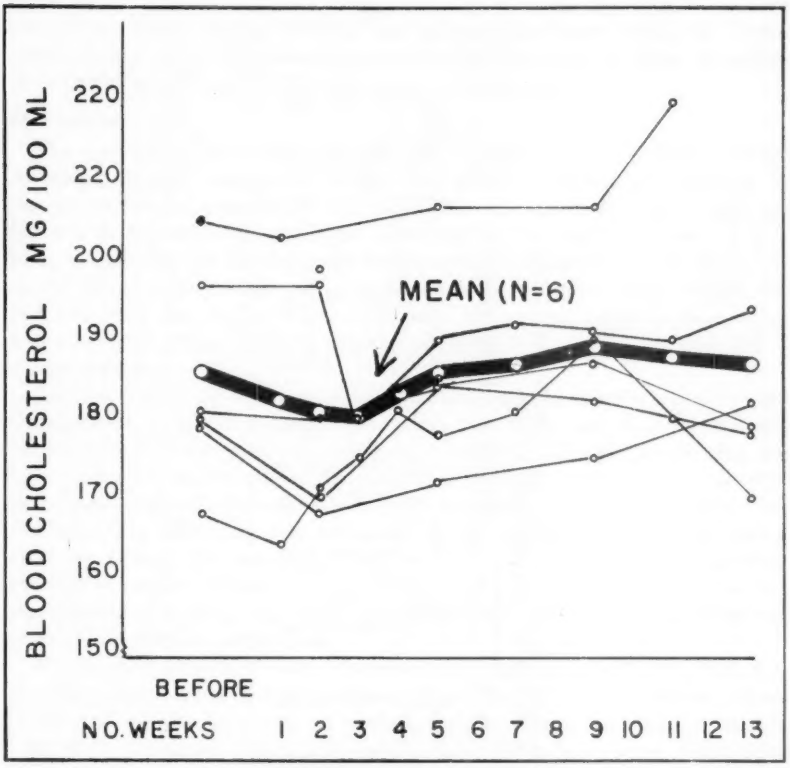

FIGURE II. Blood cholesterol levels of the control group before, during, and after the training period.

ing, but during exercise an increase occurred in every instance. This is probably indicative of fat mobilization and ultimate utilization during physical exercise.

The diurnal variation computed from the three resting cholesterol determinations was found to be rather small. The average deviation from the mean was 4.17 mg. percent indicating 2 percent variability. The weekly variability

TABLE 3.—COMPARISON OF THE MEAN CHOLESTEROL LEVEL OF EXPERIMENTAL GROUP BEFORE EXERCISE AND IMMEDIATELY AFTER EXERCISE

Condition	Mean (mg %)	Difference Between Means			
		Diff.	S.E. Diff.	t	P
Pre-exercise	192				
Postexercise	209	17	2.404	7.071	.001

TABLE 4.—BLOOD CHOLESTEROL, SKINFOLDS, AND WEIGHT CHANGES DURING A PHYSICAL TRAINING PROGRAM

	LEVELS					SKINFOLD MEASUREMENT											
	Body Weight		Cholesterol Levels			Abdomen			Hips			F. Thigh			R. Thigh		
Subjects	B	A	B	A		B	A		B	A		B	A		B	A	
1	130	129	177	152	—25	9	8	1	7	6	1	11	10	1	9	9	0
2	186	188	220	225	+ 5	8	9	1	7	7	0	7	7	0	8	7	1
3	165	156	200	170	—30	11	8	3	13	10	3	12	9	3	11	9	2
4	205	190	188	152	—36	31	18	13	27	17	10	15	11	4	14	10	4
5	184	182	263	235	—28	328	22	6	25	21	4	12	11	1	12	10	2
6	185	182	170	143	—27												

parallels the diurnal variation, being 5.43 mg. percent denoting 2.7 percent variability. These figures indicate that plasma cholesterol levels are rather stable during the period of time represented in this study. A paper to include the variability of blood cholesterol is now being prepared.

Discussion

The findings of this study support the hypothesis that physical exercise decreases plasma cholesterol levels. The same proportionate decrease in plasma cholesterol occurred in one individual who lost both body weight and fat and in one who did not. One individual had a slight decrease of both body weight and fat but the same approximate decrease in blood cholesterol as the others. Still another who showed virtually no loss of body weight, but did lose body fat, had a decrease in blood cholesterol equal to that of the average of the group. Table 4 contains the data of body weights and fatfold measurements.

The possibility of physical activity having a prophylactic effect on the development of coronary heart disease has been advanced. J. N. Morris and associates (36) compared the death certificates of 31,000 bus drivers and bus conductors employed by the London Transport System. They observed that fatal heart attacks were much more frequent among drivers than conductors. This difference was attributed to the physical exercise conductors received during the course of their work. They were able to substantiate these preliminary findings by obtaining similar results on postmen as representatives of a physically active occupation and postal clerks as representatives of a sedentary occupation.

Morris and Crawford (35) examined the autopsy reports of 3800 noncoronary heart disease deaths. The findings show that heart disease occurs in inverse ratio to heaviness of work. Large healed scars in the left ventricular wall, presumed healed myocardial infarction, were three times more common among men who had been engaged in light occupations as compared to men involved in heavy labor. Further, such scars were four to five times more common among light workers in the 45-59 age group. More recently Taylor (45) reports similar results in making comparisons between railroad clerks and switchmen and railroad clerks and maintenance employees, new track laying crew. Individuals in a sedentary occupation had a higher incidence of heart disease as compared to individuals in a more physically active occupation. It is interesting to note that individuals engaged in a physically active occupation have lower blood cholesterol levels as compared to those in a sedentary occupation (5, 25). This difference has been attributed largely to the diet and, more specifically, the fat content of the diet.

In studying further populations of various kinds regarding plasma cholesterol level, emigration of apparently healthy individuals, who have low cholesterol values, from a comparatively uncivilized community to one more advanced and economically independent, results in the acquisition of the average cholesterol level of their country of adoption. An example of this is the work of Toor and associates (46). In studying Japanese in the United

States, Hawaii, and Japan, Keys and associates (27) found the highest cholesterol levels and incidence of coronary heart disease among Japanese in the United States. More recently, Groom and associates (20) compared the autopsy reports of negroes of Haiti and American negroes and found the degree of atherosclerosis in the coronary arteries to be twice as great in American negroes. It was postulated that differences were due to causes other than diet. Factors suggested were stressful environment, mechanization, and competitiveness. One can easily understand that this difference could be influenced by a lack of physical activity.

In what ways and by what means does physical activity influence cholesterol metabolism? Page and others (39) state that "Cholesterol is normally esterified with unsaturated fatty acids, and when these are unavailable, cholesterol esterifies with saturated fatty acids provided by the dietary fats or synthesized in the body from carbohydrates. It is these saturated cholesterol esters which tend to be deposited in the arterial intima." Kritchevsky (30) states that the liver is the primary organ for cholesterol synthesis and catabolism. The cholesterol-protein complexes circulate by way of lymphatics and veins back into the blood. This cycle occurs repeatedly for several days until the circulating sterol is withdrawn for utilization or degradation. An excess of circulating cholesterol results in a higher percentage of fat being deposited on the arterial walls.

Physical activity, by increasing metabolism, speeds up the processes of cholesterol excretion and also prevents synthesis of this sterol. Physical activity results in a greater mobilization and alimentary assimilation of cholesterol and thereby lowers it in the blood (37). Cholesterol mobilization is enhanced by the massaging action of muscles in clearing fats from the arterial walls which lowers the rate of fat deposition. Page (38) states that atherosclerosis occurs much more severely in places where the blood vessels are not subjected to the massaging action of muscles. Wolffe (52) found atherosclerosis to be higher in 300 middle-aged sedentary individuals, compared with an equal number of athletes. One can only postulate whether physical training produces its benefical results by decreasing the blood cholesterol level or by increasing collateral circulation and circulatory efficiency. In all probability, both factors play an important role. Bortz (6) say: "Muscles become flabby from lack of exercise; when the blood stream flows at a slow rate, sludging of cells and metabolites occurs. There is more opportunity for deposition of cholesterol, triglycerides, and fatty acids to settle in crevices in the intima and media of blood vessels." He further states, in generalizing the work of Dock (12), that "more attention will be given to lack of physical activity than on excessive effort as an etiologic factor in causing vascular disease. He also emphasized that lack of exercise is an important factor in raising blood cholesterol."

Gordon (17) describes in some detail the importance of acetic acid, as Acetyl Co-A, carbohydrate and fat metabolism. He advances the possibility that the cholesterol lowering effect of physical activity may be due to the generation of a metabolic fuel, DPNH, in striated muscles, which tends to

suppress cholesterol synthesis, thus lowering cholesterol levels. This, however, appears to be contradictory to the results of this study since the cholesterol level was always increased during exercise. Balke (3) also found the cholesterol level to be increased during exercise.

Cholesterol metabolism has been shown to be closely associated with the functioning of the endocrine system, but the mechanisms are still somewhat obscure (9). The adrenal glands lower cholesterol by converting it to corticosteroids. Powers and DiLuzio (42) were able to show that the adrenal glands make a significant contribution in the regulation of plasma lipid and cholesterol metabolism. Hurxthal (23) has found lower cholesterol levels in hyperthyroidism and elevated levels in hypothyroidism. Hyperthyroidism is associated with increased destruction and intestinal excretion of cholesterol by its conversion to acidic products. Kritchevsky (30) is of the opinion that a lack of the male sex hormones, androgens, is associated with increased levels of cholesterol. The female sex hormones, estrogens, have a cholesterol-lowering effect in man. The beneficial effects of physical exercise in the regulation and improvement of the glandular system will not be discussed in this report. Cureton (11) presents a rather extensive review of the literature and the beneficial effects of exercise on the glandular system.

It has been shown that populations with a high average total blood cholesterol also have a high rate of coronary heart disease. Evidence presented indicates that individuals engaged in a physically active occupation have lower cholesterol levels and incidence of coronary heart disease than those engaged in a sedentary occupation. However, it has also become clear that the lack of physical activity alone cannot be made responsible for the increasing mortality from degenerative cardiovascular diseases. Diets consisting principally of highly saturated fats result in elevated levels of blood cholesterol. On the other hand, diets containing a high percentage of polyunsaturated acids, mainly linoleic acid, lower blood cholesterol (1, 18, 24, 26, 28, 54). Stresses of various forms have been shown to increase blood cholesterol (7, 15, 21) and also lower blood lipids (7, 32). It then appears that no one single factor can be made fully responsible for the present-day high rate of degenerative heart disease, but rather a combination of factors.

Conclusions

Within the limitations of this study, the following results were apparent:

1. Physical training (two-mile run for time, five days a week, for a period of five weeks) produced a significant decrease in plasma cholesterol.
2. A significant temporary rise in cholesterol occurs during exercise, possibly denoting fat mobilization.
3. The plasma cholesterol level of each of the experimentals returned to pretraining levels within four to six weeks after training was stopped.
4. Plasma cholesterol levels of the control group remained approximately the same throughout the entire 16 weeks of testing.
5. Diurnal and weekly variations were very small, 2 percent and 2.7 percent, respectively.

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Notes & Comments

NOTES

Relationship between Patellar Tendon Reflex Time and the 35-Yard Dash in 6th and 7th Grade Boys

PAUL W. HUTINGER
Health and Physical Education Office
Kansas City, Missouri

THE PURPOSE OF this study was to investigate patellar tendon reflex time as a possible factor in the speed of running for elementary school boys. The patellar reflex was chosen since, because of its simplicity, it is an important model for study. It can also serve as an indicator for more complex processes integrated by the central nervous system.

Review of Literature

The writer found in a recent study (4) that Negro boys and girls of the 4th, 5th, and 6th grades had statistically significant faster times for the 35-yard dash than a comparable group of white children. Browne (1), in his study of patellar reflex times, found that Negroes had a faster reflex. The mean patellar reflex time of 82 white subjects was .0861 $\pm$ .0013, which the mean patellar reflex of 81 Negro subjects was .074 $\pm$ .0009. Lautenbach and Tuttle (5) found the correlation coefficient of .815 between speed in sprinting and reflex time.

Chaney (3), in his study of tendon reflexes, states that the latent period of response cannot be studied unless it varies markedly from the normal. He cited the normal response for Achilles tendon reflex at .05 seconds, comparable to the patellar tendon reflex time in this study. Buller (2), in studying the reinforcement of tendon reflexes, found that a reinforcement action, such as a firm grip of the hand, does not affect the sensitivity of the anterior-horn cells but appears to act on the small motor system and intrafusal muscle fibers. He cited norms of .4 to .7 for normal subjects.

Procedure

Eighty-two 6th and 7th grade boys from the public elementary schools of Kansas City, Missouri, were used in this study. Lockhart's survey of timing devices (6) was consulted, and a brush recorder was used for the timing device. It had variable speeds of 1, 5, 25, and 125 millimeters per second. Preliminary testing with the instrument indicated that, for greater accuracy in measuring the response time, the 125 millimeter per second speed would have to be utilized. A circuit was set up with two microswitches and a one and a half volt battery. Using the first and second trials, the reliability of the instrument was found to be .93.

The following procedure was used in gathering data for the patellar tendon reflex. The heel of the subject was placed against the microswitch attached to the leg of the testing table. This switch was wired so that a light was on when the switch was closed. The second microswitch was attached to a block of wood, making a hammer used to strike the patellar tendon. The brush recorder registered the closing of the hammer microswitch as it struck the subject's patellar tendon and the opening of the heel microswitch as the subject responded.

Each subject was given three trials, and the fastest time was recorded. The distance between the closing of the hammer microswitch and the opening of the heel microswitch was measured to find the speed of response.

To test speed, the subjects were timed on the 35-yd. dash. The distance was short enough that endurance was not an influencing factor, an important consideration for this grade level. The subjects were given two trials, ten minutes apart, and the faster trial was recorded. Due to slow starting, motivation to run fast, and slowing before crossing the finish line, there is a great variance in the time of inexperienced runners at this grade level. After running the first trial, each boy's time was compared with the times for the others in the class, and they were encouraged to run faster on their second trial.

Conclusion and Discussion

The correlation coefficient for patellar tendon reflex and 35-yd. dash times was —.017. This low negative correlation coefficient indicated that for this group of 6th and 7th grade boys there was no relationship between the two factors.

Some of the boys were still developing physically and had not reached puberty. This is a possible explanation for the fact that this study did not follow the trend indicated by the studies of college athletes. It is possible that the motivation was not great enough, so that true potential speed was not realized. Although speed of running may be an inherent factor at this age, practice and training could possibly make a greater difference than with adults.

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COMMENTS

Sympathetic versus Vagus Influence upon the Contractile Vigor of the Heart

THOMAS K. CURETON
University of Illinois

The articles of H. J. Montoye (17) and E. D. Michael, Jr. (16) show that the brachial pulse wave obtained on the Cameron heartometer has a certain validity for prediction of endurance and fitness. Neither article gives much on the interpretation of the brachial pulse wave, and in view of recently ascertained facts these articles deserve a comment.

The article of Michael shows that there is a progressive increase in amplitude of the brachial pulse wave, and especially of the diastolic wave, and diastolic surge parallel with progressive training of the endurance type. In general, endurance athletes have taller and sharper waves, with a stronger systolic wave rising to a taller and sharper peak (the angle between the sides of which we have called the "ejection angle") and a more distinct and taller secondary (diastolic surge) wave. The amplitude of the systolic wave is significantly correlated with endurance performance, as is also the amplitude of the secondary wave, and usually, best of all, the amplitude of the diastolic surge, i.e., the portion of the secondary wave above the level of the dicrotic notch. With 67 young men, well distributed as to ability, we demonstrated that the *raw* rectilinear Pearson r was 0.63 for the area of the Cameron heartograph and the time of the all-out treadmill run (7 mi./hr., 8.6% grade), and it made little difference whether or not we divided the area of the pulse wave by the surface area of the body. This correlation became 0.70 calculated as eta (correlation of curvilinear relationship). The small ejection angle, taken between the sides of the anacrotic and catacrotic slopes, of the systolic wave correlated —0.475 with the same treadmill run time but was 0.58 calculated as an eta. This same ejection angle correlated —0.345 with the ejection velocity of the systolic wave, with velocity measured as the distance measured over the whole anacrotic side of the wave divided by the time of the wave to rise from the base line to the peak. This small angle of ejection correlated 0.94 with the larger obliquity angle originally defined by Cameron, this having the catabolic slope line drawn through the center hole in the circular graph.

In an unpublished study Willett (22) reported the following correlations, based upon 66 young men:

Significant	*Pearson r*	*P.E.*
Diastolic pulse wave amplitude	0.555	0.060
Systolic pulse wave amplitude	0.528	0.062
Obliquity angle	—0.513	0.064
Area under the pulse wave	0.470	0.067
Diastolic surge (amplitude above the dicrotic notch)	0.405	0.067
Diastolic time/systolic time	0.328	0.077
Insignificant		
Pulse pressure	0.263	0.080
Pulse rate	—0.256	0.081
Systolic blood pressure	0.233	0.082

In the above list of correlations only the heartograph vertical deflections and angles are significant, and the pulse rate and blood pressure measures are insignificant. The multiple R for a combination of the first six variables was calculated as 0.70 to predict treadmill running time (7 mi./hr., 8.6% grade).

A study was made by Tosky (20) which related the heartograph as taken on the Cameron heartometer to time of the all-out treadmill run (10 mi./hr., 8.6% grade). The analogy in this study was to use as output the area of the brachial pulse wave, and as output/size of heart the ratio of area of brachial pulse wave/area of frontal X-ray, both in sq. cm., was used. The following correlations were obtained:

Significant	*Pearson r*	*P.E.*
Area of brachial pulse wave/area of frontal X-ray	0.568	0.098
Area of brachial pulse wave/heart volume by Keys eq.	0.528	0.104
Area of brachial pulse wave	0.436	0.117
Area of brachial pulse wave/surface area of body	0.477	0.111
Insignificant		
Grollman stroke volume	0.271	0.134

Cureton and Massey (6) reported that endurance on the treadmill was related to systolic amplitude, diastolic amplitude, diastolic surge, and angle of obliquity, combined in a multiple regression equation, R = 0.70. The reliability of this treadmill run using young men was shown to be 0.91. The heartograph amplitude measures systematically deteriorated progressively at simulated altitudes in a decompression chamber at 5,000, 10,000, 15,000, and 20,000 feet, with cuff pressure remaining the same, and with blood pressures unaffected. All heartograph measures listed above differentiated athletes from nonathletes. Depletion of oxygen levels lowers the amplitude.

Several workers have attempted to relate the stroke volume of the heart to the area or amplitude of the brachial pulse wave. Michael (14), using the Grollman method for average stroke volume and relating this to the systolic amplitude of the brachial pulse wave, obtained a correlation of 0.91 in a virtual straight line proportionality, using 21 young men well distributed in ability. Michael and Cureton (15) later demonstrated the effects of training upon the cardiac output with the same methods.

Various physiologists have persisted in their attempts to relate beat to beat stroke volume to various pulse wave measures. Most of these studies have used the Hamilton type of manometer, with the Cournand needle inserted into the brachial artery rather than an external cuff as used with the heartometer (8, 10, 12, 21). In general, there are some discrepancies as no exact method has been devised to make the comparison, but, as reported by Kroeker and Wood (12), the method of pressure pulse is quite satisfactory under controlled conditions to indicate beat to beat stroke volume. Warner, Swan, and Wood (21) give the average discrepancy between the dye and pressure pulse determinations to be 10 perceint. Duntas (7) seems to be the only one who has compared the externally taken cuff taken pulse waves with the needle method. He inserted a 15-gauge Cournand needle into the brachial artery of 10 young men and then took simultaneous cuff type pulse waves, obtaining both intra and extra pulse waves. While the externally taken cuff type pulse waves varied markedly with cuff pressure, they were quite reliable, and the extra-arterial pulse waves closely resembled the intra-arterial pulse waves at near diastolic level of cuff pressure. After making a careful investigation in 1947 of the influence of cuff pressure (13), we have long taken the waves at slightly above diastolic level and with young men have occasionally standardized the cuff pressure at 80 mm. Hg. Duntas' study (7) demonstrated that vasoconstriction markedly reduced the extra-arterial pulse wave from the brachial artery, attributing this reduction to a reduced compliance of the arterial wall. It was also determined that acetycholine and vagal stimulation diminished the circumference excursions of the brachial artery. Duntas has suggested a better name than heartograph, namely, "*pressure* plethysmograms." He points out that the loss of elasticity and increased peripheral resistance will prolong systolic duration, i.e., increased crest times are bad; he further suggests that the brachial pulse waves will prove to be valuable in following cardiovascular deterioration with age.

A factor analysis by Sterling (19), working with Cureton, at the Physical Fitness Research Laboratory, at the University of Illinois, Urbana, throws some additional light

upon the meaning of the brachial pulse wave in the whole complex of cardiovascular measurements. The largest and most significant of eight factors extracted from a series of 104 cardiovascular measures, both quiet and dynamic, was first, a *brachial pulse wave factor,* with 29.04 percent variance. The second was an *oxygen requirement factor* with 16.04 per cent variance[b] third, a *pulse pressure after exercise factor* with 10.93 percent variance; fourth, *body weight* with 7.22 percent variance; fifth, *pulse ratio factor,* indicating adjustment to submaximal work and recovery therefrom with 5.94 percent variance; sixth, *pulse rate,* indicating vagus tone, with 5.08 percent variance; seventh, *aerobic efficiency and run time* with 3.92 percent variance (not including oxygen debt); and eighth, indicating blood sag, *decrement between sitting and standing brachial pulse wave amplitudes.*

The main point of this comment is to indicate that the vertical amplitude of the brachial pulse wave, as determined on the Cameron heartometer, is the most valid measure of cardiovascular fitness in the quiet state which is available to physical educators at this time. Four fairly extensive reviews of the evidence for this statement have been published by Cureton (2, 3, 4, 5). From 1945 to 1951 several thousand subjects were measured and compared in the bracial pulse waves with Cureton's technique for taking and quantitating the waves. No claim was ever made for measuring stroke volume *exactly,* but the proportionate measures closely paralleled the stroke volumes as determined by the dye, acetylene, catheterization, and ballistocardiographic methods, as Cureton's graph (5) shows, plotted for various ages.

The most important point to realize is that the brachial pulse wave measures more than pulse rate. Montoye (17) found that the time made by runners in a championship NCAA cross country race, at East Lansing in 1958, correlated 0.62 with the time, and the highest vertical deflection from the heartograph correlated —0.448. The heavy snow caused about one-third of the runners to refuse to run in this race. The sample obtained was a very restricted sample, which usually produces very low correlations, and unusual complications accompanied this race. Since Montoye had very inadequately reviewed the literature, especially several studies available at the University of Illinois, a more adequate review and analysis are indicated.

Several of our studies have shown *curvilinear* relationships between the amplitude of the brachial pulse wave and the treadmill run time, the Willett-Cureton data (22) giving for area vs. run time eta = 0.70; the same data giving for amplitude of the systolic wave and run time, eta = 0.80. The time (measured horizontally) and systolic amplitude (measured vertically) are measures of different components as our factor analysis study has shown. The vertical amplitude is undoubtedly dominated by sympathetic stimulation, whereas vagus tone controls the pulse rate. A brachial pulse wave is, of course, an area (force x time diagram) which includes both of these aspects. It has long been our observation after testing several thousand athletes of many different types that the endurance athletes have taller, sharper systolic amplitudes than the others and are significantly differentiated from normal subjects even more in amplitude than in horizontal time. It is also an anatomical fact pointed out by Clark that the vagi do not extend into the ventricles but stop in the auricular area, whereas the sympathetic nerves extend into and permeate the ventricles. The development of the ventricles with endurance training, which has long been noted in X-ray and stroke volume studies, would logically relate to strong sympathetic stimulation, hence, taller and sharper pulse waves. Rushmer and colleagues (18) held the rate the same and demonstrated that the immediate response of the ventricles was a stronger and faster ejection stroke when the sympathetic nerves were stimulated, and that the vagi had no effect upon the contraction energy, speed, or stroke volume.

Certain drugs have long been known to influence ventricular action of the heart. Rushmer (18) also demonstrated that an enlarged output and force of the systole of the ventricles followed injection of isopropyl arternol; that this effect was much the same as in exercise with tachycardia, increased ventricular pressure, reduced diastolic pressure, and peripheral resistance; but that the ventricular response was mild to 1-

epinephrine and norepinephrine compared to direct mechanical stimulation of the sympathetic nerves. It has been known that exercise is mainly a sympathetic type of stimulation, acting to train the sympathetic nerves, but obviously, since pulse rate slows in training, the vagi are similarly and simultaneously trained. We have a number of example of men developing augmented amplitudes in the brachial pulse waves and simultaneously faster pulse rate, this generally occurring upon psychic stimulation before a race. Adrenaline has been shown to increase the force and amplitude of contraction of the ventricles (1, 11).

The conclusion is reached, therefore, that to consider the brachial pulse wave valuable only as a nindicator of pulse rate is to ignore many data to the contrary. We determined an equation from Sterling's data to predict the energy of the pulse wave taken with the Cameron heartometer. This equation is: (in standard 6 σ scores) N = 67 young men:

$$Z_o \text{ (S.S.)} = 0.550\ Z_1 \text{ (S.S. for Systolic Amplitude)} + 0.495\ Z_2 \text{ (S.S. for Diastolic Amplitude)}$$

The relationship is curvilinear with run time on the treadmill in an all-out run. This factor Z_o is Sterling's Factor I and is related 0.881 (eta) to the angle of ejection of the systolic stroke of the pulse wave, and the latter is correlated 0.842 with the ejection velocity in cm./sec. This gives a sharper, more exact way to estimate the persistent sympatheticotonic effect from the pulse wave in the quiet state, mainly due to physical training but sometimes due to emotional stimulation. Usually, the taller and sharper the wave spikes, the greater the sympathetic stimulation, whereas the slower the pulse rate, the greater the vagus stimulation to the heart.

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(Submitted December 15, 1960)

Research Abstracts

Prepared by the Research Abstracts Committee of the Research Council, D. B. VAN DALEN, Chairman

129. Benzinger, T. H. "The Human Thermostat." *Scientific American* 204:134-147; January 1961.

It has long been known that the normal body has the ability to maintain a constant internal temperature. When that temperature is too high, an automatic control located in the hypothalamus sets off dilation of surface blood vessels and the process of sweating. If quantitative measures of internal temperature and surface loss of heat could be concurrently observed, insights should develop which would enable medical science to aid temperature control when the automatic process failed to function. A human gradient calorimeter, developed at the Naval Medical Research Institute at Bethesda, Maryland, large enough to hold a man stretched out at full length, measures the total energetic output from the skin. Observations of this output and rectal temperature showed no relationship. This suggested that rectal readings might not be directly related to internal temperature and a thaormocouple was introduced through the outer ear and held against the eardrum membrane which shares a common blood supply with the hypothalamus from the internal carotid artery. The relationship was now apparent.

The author points out that the warm sensitive nerve endings in the skin have no function in the regulation of body temperature but that they operate via the centers of consciousness in the cortex by-passing the unconscious control in the hypothalamus, which is the site of a receptor end-organ. Here is measured and regulated the temperature of the blood which bathes its cells and the rest of the brain; the thermostat is in the interior of the head where it properly belongs.—*Ruth B. Glassow.*

130. Billings, C. E. Jr.; Tomashefski, J. F.; Carter, E. T.; and Ashe, W. F. "Measurement of human capacity for aerobic muscular work." *Journal of Applied Physiology* 15: 1001; November 1960.

An investigation of Balke's treadmill test (grade increased 1 percent per minute, walk at 3.5 mph) of aerobic work capacity was conducted in an effort to simplify it and extend its use to the study of cardiopulmonary disease. It would appear that the authors have complicated the test rather than simplifying it by using the concept of reserve area R_A (area above the actual pulse rate curve and below a pulse rate of 180) as a scoring device rather than time to reach a pulse rate of 180 (T_{180}) as originally used by Balke. Their rationale for this innovation was that the heart rate response pattern displayed wide interindividual variation even though time was constant to T_{180}. Although a correlation coefficient between R_A and T_{180} was not reported, one between R_A and T_{150} was 0.984 ± 0.002. Deviation from a linear relation as discerned from a visual inspection of plotted data only occurred if exercise was terminated before five minutes had elapsed. While the authors apparently intend to use this test for patients with cardiopulmonary disease, the study was performed on normal male university students. Since many patients with cardiac problems can not walk at 3.5 mph and their pulse response to exercise will be highly abnormal because of abnormal cardiac rhythms, modification of the test procedure and performance criteria will probably have to be made—*E. R. Buskirk.*

131. Case, Harry W., and Stewart, Roger G. "Development of a Driving Attitude Scale." In Highway Research Board, *Driver Characteristic and Behavior Studies.* (Bulletin Number 172).

To obtain descriptions of real traffic situations for this scale, 2 clinical psychologists conducted informal interviews with 300 habitual traffic violators. The violator described

the manner in which he had received recent traffic citations and expressed himself freely regarding the actions of other drivers and police officers in those traffic situations. 100 multiple choice items were built to represent traffic situations experienced by most drivers. 55 surviving items are undergoing preliminary validation. Test results have been obtained from a group of university students, and testing of traffic violators is proceeding. For certain items, results from the students show statistically significant differences between groups in terms of traffic citations received. Certain items also differentiate between groups in terms of reported highway driving speed under different conditions.—*D. B. Van Dalen.*

132. COSTELLO, C. G., and EYSENCK, H. J. "Persistence, Personality, and Motivation." *Perceptual and Motor Skills* 12:169-170; 1961.

In a study of persistence on the dynamometer of 72 children the more extraverted were found to be significantly more persistent. No differences were found with respect to neuroticism or sex.—*D. B. Van Dalen.*

133. DURNIN, J. V. G. A. "Appetite and the relationships between expenditure and intake of calories in man." *Journal of Physiology* 156:294; April 1961.

Previously published measurements of energy intake and expenditure for seven-day periods in 69 subjects of both sexes were analyzed to determine the best relationship between 24-hour intake and expenditure. The correlation between intake and expenditure on the same day was positive and significantly different from zero in only four of the 69 subjects. In four other subjects a significant negative correlation was observed. In addition the following patterns were apparent: (a) no correlation between intake and expenditure but intake significantly higher than expenditure, (b) no correlation but expenditure higher than intake, (c) no correlation and no difference between intake and expenditure, (d) positive correlation but intake significantly higher than expenditure. In 41 subjects intake and expenditure were balanced over the seven-day period indicating a more precise regulation of appetite over seven days as compared to one day. No better relationships could be found when intake was matched to energy expenditure on the previous day or two days previously.

Because of the variety of responses observed, application of theories of short term appetite regulation as formulated from studies of lower animals would appear to be a tenuous procedure. A mechanism for control of long term regulation remains to be elucidated.—*E. R. Buskirk.*

134. WOLFF, H. S. "Modern Techniques for Time and Motion Study in Physiological Research." *Ergonomics* 2: 354-62; August 1959.

Two methods are described by which a small and relatively untrained staff can record and evaluate time and motion study data for a number of subjects over extended periods of time. Use of a radio link permits one observer to remain in close contact with his subjects; the multichannel integrating clock, and the use of punched cards can permit the study of at least 12 subjects by one recordist. Where data obtained are used to calculate energy expenditure, the value is generally lower than that obtained by direct measurement. This may be due to added energy expended in changes of component activity which bring associated postural changes or variations in speed of movement.—*David H. Clarke.*

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